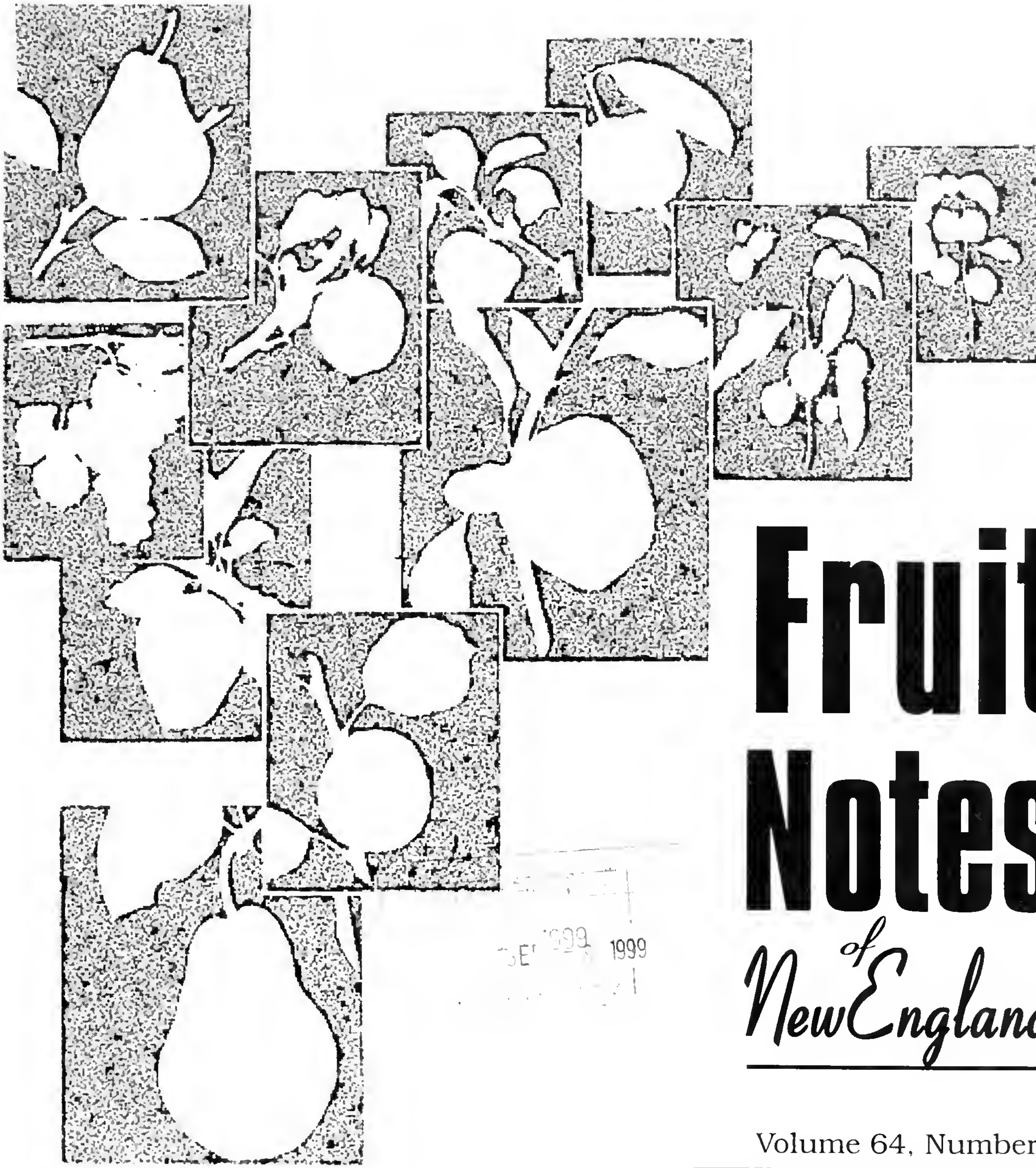

Fruit Notes of New England

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A Note from the Editors

Fruit Notes has been published for 63 years by pomologists at the University of Massachusetts (actually at the Massachusetts Agricultural College in the beginning). During these years, it has evolved considerably but always has focused on issues of importance to fruit growers. Today's subscribers live primarily in New England, but many are from other tree-fruit-producing states and several other countries.

With this issue, the first of its sixty-fourth year, *Fruit Notes* is embarking on new and exciting changes. First, the cover is redesigned, but most importantly it is becoming *Fruit Notes of New England.* We hope to have regular contributions from individuals in the other New England states.

Within the articles, the first evidence of this change is the discussion written by Jan Nyrop on the use of mite predators. This paper, although not written by a New England author, was presented at the 1999 Annual Meeting of the Maine State Pomological Society. In fact, *Fruit Notes* subscription will be a benefit of membership in the Maine State Pomological Society, and *Fruit Notes* will publish papers presented at meetings of the Society.

The editors are excited about these changes and hope that they result in a significant improvement in the quality of this publication. If you have any questions or comments, please contact us at the address provided inside the cover.

Making Integrated Mite Control Work in Northeast Apple Orchards

Jan P. Nyrop
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European red mites (ERM), *Panonychus ulmi*, feed on leaves of apple trees and thereby interfere with photosynthesis and production of carbohydrates. At high levels, ERM damage to apple leaves reduces fruit yield and quality. As a general rule, keeping ERM numbers below 2.5 per leaf before July, below 5 per leaf during July, and below 7.5 per leaf in August will prevent economic losses from this pest.

Three strategies can be used to control ERM in apple orchards. First, protectant miticides (e.g., dormant oil or an ovicide) can be applied early in the growing season. Second, pest mite numbers can be monitored and miticides applied if densities exceed threshold levels. Third, natural enemies that feed on ERM can be encouraged and managed to constrain pest mite numbers. Strategies based solely on miticides are relatively expensive and eventually lead to the development of resistance by ERM to the miticides. With the help of natural enemies, the cost of managing ERM in apples can be greatly reduced and resistance delayed.

Insect and mite predators, including several species of phytoseiid mites, stigmaeid mites such as *Zetzellia mali*, and ladybird beetles, feed on ERM. Phytoseiid mites are the most effective of these predators in the Northeast. Several species of phytoseiid mites, including *Amblyseius fallacis, Typhlodromus pyri, T. occidentalis, T. vulgaris*, and *A. cucumeris*, can be found in commercial orchards. Species cannot be identified in the field because they are so similar in appearance. They are only distinguishable through microscopic examination of the arrangement of the setae (hairs) on their bodies. *T. pyri* and *A. fallacis* are the two most common species in Northeast orchards. Of the two, *T. pyri* is better able to regulate ERM populations. This is the species that should be established and maintained for biological mite control in Northeast orchards. In this article I answer three questions: First, why is it that *T. pyri* is such an effective predator? Second, is *T. pyri* an effective predator throughout the northeast? Third, how can you make use of this natural enemy to provide cost-free mite control?

Why is *Typhlodromus pyri* such an effective predator? For many years *A. fallacis* was promoted as an effective biological control agent for ERM. In truth, *A. fallacis* gives sporadic and unreliable ERM control, while *T. pyri* is highly effective in this capacity. Differences in effectiveness of *T. pyri* and *A. fallacis* as biological control agents are rooted in their biologies.

T. pyri require approximately 32 days to complete a generation, and have three to four generations per year. They overwinter as mated adult females on trees wherever they can find a protective site (e.g., bark crevices, branches, spurs). Adult females emerge from overwintering sites on warm spring days before budbreak. The adults live about 20 days and lay an average of 20 eggs starting as early as tight cluster or pink bud growth stages. Eggs are usually laid on the undersides of leaves along the midrib. The eggs hatch in 1-3 days and resulting immatures are nearly transparent and look like smaller versions of the adults. Immatures and adults feed on a wide variety of food sources, including pollen and rust mites, along with ERM and two-spotted spider mites (*Tetranychus urticae*). An adult female will consume one to two ERM adults or three to four ERM nymphs per day. These predators do not concentrate on leaves with large numbers of ERM, unlike some other phytoseiids (e.g., *A. fallacis*). *T. pyri* are relatively winter hardy and remain in the tree even when ERM are scarce, feeding on alternative food sources.

A. fallacis require 16 days for each generation,

with four to six generations per year. These phytoseiids may also overwinter as adults in trees if prey are available to feed on in late summer and early fall; otherwise, they disperse from the trees and overwinter in the ground cover. Occasionally, they can be found in trees when ERM eggs start to hatch just before bloom, but are usually scarce until mid-July because of high winter mortality or lack of ERM as a food source before bloom. Adult *A. fallacis* lay twice as many eggs as *T. pyri*, immatures and adults consume nearly a third more ERM per day than *T. pyri*, and immatures develop into adults in a third of the time required by *T. pyri*. *A. fallacis* feed mainly on spider mites. Therefore, when prey mite numbers are low in the trees, *A. fallacis* will disperse out of the trees to locate another food source, possibly in the ground cover. *A. fallacis* are more effective at reducing high red mite populations than *T. pyri*, but this is often after ERM have done considerable damage to the leaves.

Based on generation time, oviposition rate, and prey consumption, it would appear that *T. pyri* is a less effective biological control agent than *A. fallacis*. But the advantages *T. pyri* has over *A. fallacis* are its greater winter hardiness, its use of alternative food sources when ERM are not present, and its tendency to remain in trees when ERM are scarce. When ERM numbers are low, *T. pyri* will stay in the tree canopy feeding on pollen and rust mites, and will continue to be a presence as ERM numbers start to rise.

Because *A. fallacis* are often absent from trees or are in very low numbers in trees in early spring, ERM often build to damaging levels before *A. fallacis* exercise control. *T. pyri* will consistently maintain ERM populations at low levels provided these predators are conserved. *T. pyri* usually cannot control ERM populations in excess of five to seven per leaf, and it can take 2-3 years for sufficient numbers of *T. pyri* to build in an orchard to realize biological control. Once predators are established, the benefits are great as the need for miticides can be eliminated.

Data from an orchard at the New York State Agricultural Experiment Station into which *T. pyri* were released into two blocks of Delicious trees will serve to illustrate the effectiveness of this predator. In this orchard, no miticides were used since 1991, fungicides have consisted of captan and Nova, and pesticides have been restricted to Imidan, Sevin, Bt, and Provado. Dynamics between *T. pyri* and ERM were measured between 1992 and 1997. Results are summarized in Table 1. Since 1992 ERM numbers have been kept well below threshold levels (500 mite days) and predator numbers have steadily increased. Averages shown here are the average of temporal counts from June 1 to September 1.

Is *Typhlodromus pyri* an effective predator throughout the northeast? Yes! Until recently, *T. pyri* was thought to be common in eastern north America only in central and western New York and Nova Scotia. Therefore, in 1996 we embarked on a project with cooperators in all the New England states to introduce and establish *T. pyri* throughout this region. There is no apparent reason why *T. pyri* should not survive and thrive

Table 1. Summary statistics for European red mite (ERM) and *Typhlodromus pyri* in two orchard blocks at Geneva, NY. Numbers are density per leaf.

Parameter	1992	1993	1994	1995	1996	1997
Maximum ERM	2.1	0.2	3.6	1.8	1.9	1.53
Mite days[a]	68	7	63	25	30	39
Average ERM	0.8	0.08	0.7	0.3	0.3	0.5
Minimum *T. pyri*	<0.1	0.2	0.1	0.3	0.1	0.1
Maximum *T. pyri*	0.1	0.9	0.6	1.4	1.9	2.8
Average *T. pyri*	0.02	0.5	0.3	0.9	1	1.3

[a] Mite days is the cumulative density of mites. The damage threshold is 500 mite days.

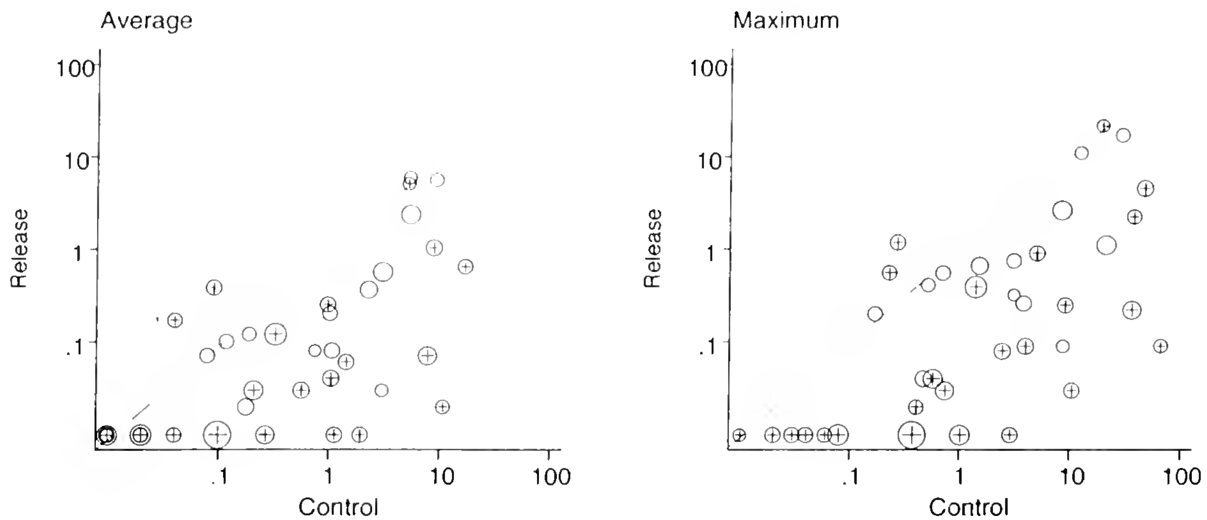


Figure 1. Average and maximum European red mite densities in 1998 in plots where *T. pyri* were released in 1996 and in control plots where *T. pyri* were not released

throughout the northeast. Possible abiotic limits are winter cold, summer heat, and low moisture during the summer. However, a review of historic climatic data raises no red flags. *T. pyri* aggregate in flowers in the spring to feed on pollen. Therefore, to collect predators for release, we collected flower clusters from an orchard at the Experiment Station and shipped these clusters with predators within to cooperators who then affixed the clusters to recipient trees. Each release site consisted of a plot of six trees into which the predators were placed and a plot of six control trees. In early July we also shipped leaves with predators on them from the same orchard. These leaves were affixed to the target trees. To measure the effectiveness of the releases, leaves were collected from the release and control sites and shipped to Geneva. There, predators were collected from the leaves and identified. In 1996 releases were made at 40 locations.

In 1996 *T. pyri* were recovered from 38 of the release plots and 16 control plots. In 1997 these numbers had changed to 36 and 19. In 1997, releases were made at two additional sites. In 1998, *T. pyri* were recovered from 38 of 38 release plots and from 33 of 38 control plots! The number of control sites where *T. pyri* were found was surprising. In both 1996 and 1997 the average number of *T. pyri* in the control plots was more than 10-fold lower than in the release plots. In 1998, this difference had to changed to only two-fold lower in the control plots. These results indicate that *T. pyri* can persist throughout the northeast and are likely indigenous.

Of course the most important question is whether these predators had any impact on ERM numbers. Shown in Figure 1 are the average and maximum ERM densities in the control and release plots 1998. The average density is the average over the sampling period which generally ran from late May to mid August. The size of the symbols in these figures represent average *T. pyri* densities and data points with a cross hatch represent sites where we predicted biological control would occur. These predictions were based on *T. pyri* and ERM densities in 1997. Where biological control was predicted to occur, no oil or ovicide was applied in 1998 for ERM control in the release plots. The dashed lines in the two graphs indicate where the data points should lie if there were no differences between ERM densities in control and release plots. European red mite were generally much more abundant in the control plots than in the release plots. Of the

26 sites where biological control was predicted to occur, at only one site was this prediction in error and this occurred because *T. pyri* were inexplicably low in number for much of the growing season.

How can *T. pyri* be used to provide cost-free mite control? Achieving biological mite control using *T. pyri* is minimally a one-step process and may require two steps. First, an environment must be established in the orchard that will allow *T. pyri* to survive and flourish. This requires that pesticides that are toxic to these beneficial mites not be used. Second, if *T. pyri* are not already present in the orchard, they must be introduced.

<u>An environment conducive to *T. pyri*</u> *T. pyri* have acquired resistance to some chemical pesticides used in commercial orchards and are innately tolerant of others. However, some pesticides are quite toxic to *T. pyri*. If biological mite control is to be achieved using this predator, these toxic materials must be avoided. Because *T. pyri* are resident in trees year round, and because these predators have a relatively slow growth rate, pesticides toxic to *T. pyri* cannot be used even intermittently (e.g., every other year) without serious disruption to biological control. A list of pesticides that can be used to control insects and diseases of apple while conserving *T. pyri* is provided in Table 2. Be advised that estimates of toxicity to *T. pyri* were obtained using predators from western NY, and there may be differences in susceptibility among predator populations indigenous to other regions of the Northeast.

<u>Introducing *T. pyri* into an orchard</u> There are situations where *T. pyri* might not be present in an orchard or where they are very scarce. This deficiency can be overcome by moving predators from an orchard where they are known to occur to a recipient site. Because phytoseiid species cannot be identified in the field, it is important that you be sure the source predators are, in fact, *T. pyri*. The best way of ensuring this is to have someone identify them for you. If this is not possible, you can be reasonably sure the predators are *T. pyri* if either of the following conditions are met: 1) The predators can be found in the trees either before or just after bloom and the predators are easily found even when ERM are scarce. 2) The predators in the source orchard were themselves introduced as *T. pyri* one or more years ago, and no pesticides harmful to *T. pyri* have been used since the introduction.

T. pyri can be moved from a source orchard to a recipient orchard in one of four ways, each of which is described below. It is best to concentrate inoculation material in the recipient orchard rather than spreading it thinly over a site. If the predators are spread thinly, few animals may be introduced into each tree, which may allow for extinction of the populations. Once *T. pyri* are established in the receiver trees, they can be spread further in subsequent years. While *T. pyri* do disperse by themselves, assisting this process will hasten biological control throughout the planting.

The first method of moving *T. pyri* from one orchard block to another is to place wood pruned from a source orchard in winter or early spring into a recipient orchard. Because *T. pyri* overwinter as adult females, prunings harbor predators, although numbers in each section of pruning are highly variable. We suggest placing all the prunings from one tree into another tree. It is probably not effective to simply spread the prunings beneath recipient trees. Pruned wood need not be placed in the recipient trees immediately after pruning, but should be placed there before or just when trees begin to produce green tissue the following spring.

The second method consists of transferring flower clusters from a source orchard to a recipient site. *T. pyri* move into flower clusters at tight cluster and remain there through bloom, probably to feed on apple pollen. As many as two to three predators can be found in each flower cluster and surrounding leaves. To transfer predators in this manner, at least 20 flower clusters (and associated wood and leaves) should be placed in each recipient tree. The flower clusters are easily attached with paper clips, staples, or twist ties. Flower clusters may be stored for several days in a cooler before being affixed to receiver trees.

The third method of transferring *T. pyri* consists of collecting leaves during the summer from trees where *T. pyri* are abundant, and placing them into recipient trees. Leaves are easily affixed to the target sites using staples. The number of leaves to use depends on the density of *T. pyri* in the source orchard. As a guide, at least 50

Table 2. Relative toxicity of pesticides[1] to the mite predator, *Typhlodromus pyri*. Materials with a low toxicity can be used when needed. Pesticides with moderate toxicity should be used sparingly. Those with high toxicity must be avoided.

Pest	Low toxicity	Moderate toxicity	High toxicity
Apple scab	Nova, Rubigan, or Procure in combination with captan	mancozeb or metiram (EBDC fungicides), or Ziram before bloom	mancozeb or metiram (EBDC fungicides), or Ziram after bloom
Powdery mildew	Nova, Rubigan, Procure, Bayleton, sulfur		
Fire blight	Fixed copper, streptomycin		
Black rot	captan, benomyl or Topsin M	mancozeb or metiram before bloom	mancozeb or metiram after bloom
Sooty blotch and fly speck	benomyl, Topsin M, captan		mancozeb, metiram or Ziram after bloom
Rust disease	Nova, Rubigan, Procure, or Bayleton	mancozeb or metiram before bloom	mancozeb or metiram after bloom
Rosy apple aphid	Thiodan or Provado	Lorsban	Lannate, Vydate, dimethoate
Tarnished plant bug			pyrethroids
Spotted tentiform leafminer	Provado		pyrethroids, Vydate, Lannate
Codling moth	azinphos-methyl, Imidan, Penncap M, B.t.	Lorsban	Lannate, dimethoate
Green fruitworm	Thiodan	Lorsban	pyrethroids, Lannate
Obliquebanded leafroller	B.t., Confirm, spinosad, Penncap M	Lorsban	Lannate, pyrethroids
Plum curculio	azinphos-methyl Imidan, Penncap M, carbaryl	Lorsban	pyrethroids
leafhoppers	Provado, Thiodan, Sevin		Lannate, dimethoate, Carzol, Vydate
Apple aphids, spirea aphids	Provado, Thiodan	Lorsban	dimethoate, Lannate, Vydate
Apple maggot	azinphos-methyl, Imidan, Penncap M	Lorsban	Lannate, dimethoate
European red mite	prebloom oil, Savey, Apollo, Pyramite, Vendex	Agri-mek, summer oil, Kelthane	Carzol

[1] Check EPA and state registration status by contacting local Cooperative Extension representative. Registration status is changing annually and is not universal across all state lines. Use of product names does not imply endorsement of particular products. Read all labels for rates and timing.

predators should be released in each target tree.

The fourth method of transferring *T. pyri* is perhaps the easiest and does not carry the risks of also moving unwanted pests that the three prior methods have. Artificial overwintering sites for *T. pyri* can be created by gluing burlap to the inside of tree wrap. These composite bands, approximately 12 to 16 inches in length, are then placed on source trees in early to mid-September by stapling them around the tree bole and/or large scaffold branches. In early December, these bands should be collected, tightly rolled with a rubber band used to hold them so, and placed in a sealed plastic bag with a bit (ca. 1 in^3) of wet cotton. The bag should be placed in an insulated storage container, which in turn should be placed in a cold, though protected, environment that will buffer large temperature fluctuations. Ideally, temperatures should be maintained right at the freezing point. The following spring, the burlap bands should be placed around recipient trees at around the half-inch green bud growth stage. While the number of predators that overwinter in bands is variable, as many as 400 predators can be transferred in each band. We suggest placing a single band on each recipient tree if the bands were collected from trees that harbored moderate to high numbers of *T. pyri* (1-2 per leaf) the prior fall, and two bands in each tree otherwise.

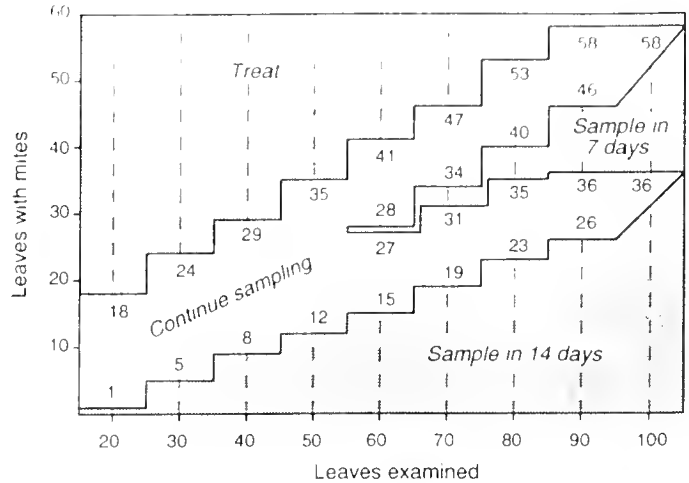
After a receiver orchard is inoculated with *T. pyri*, it often takes 2 to 3 years for the predator population to become abundant enough to regulate ERM without the need for any miticides. During this time, additional control measures are often needed to keep ERM below damaging levels. There are two key aspects to any strategy designed to do so. First, early season dormant oil sprays should be used to reduce ERM populations in the spring. These oil applications have no deleterious effect on *T. pyri*. Second, ERM numbers should be monitored, and if densities exceed threshold levels, a miticide that is not toxic to *T. pyri* should be used to control the pest mites. Note that it is actually desirable to have some pest mites in the trees after inoculation with *T. pyri* because these plant-feeding mites provide a food source for the predators and foster faster predator population growth.

A commonly asked question is, "How do you know when there are enough *T. pyri* to effect biological control?" This question is difficult to answer. While predators can be seen in the field, they are easy to miss, especially at low densities, and their impact on ERM is dependent on which species they are. Guidelines have been provided for the ratio of predators to ERM needed to achieve biological control; however, estimating these ratios is not practical. Fortunately, all that is required to determine if biological control is working is to note whether pest mites remain below threshold levels. This can be determined without regard to predator abundance. A procedure for determining whether ERM exceed threshold levels is described in the appendix. If pesticide regimes for all orchard pests can be followed that allow *T. pyri* to survive, these predators will become abundant enough to make miticide applications unnecessary.

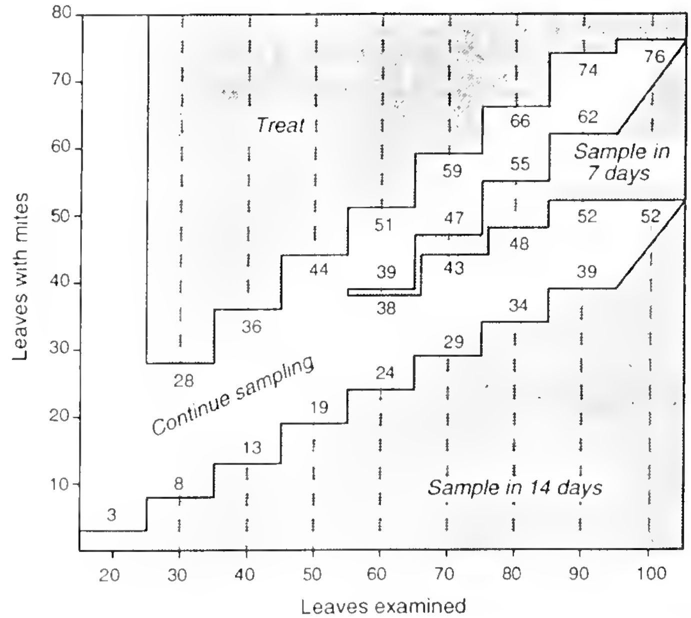
Appendix - Monitoring European Red Mite in Apple Orchards

Damage by European red mites (ERM) to apple leaves is best related to cumulative mite density, which is measured as mite-days. Apple trees with a normal crop load can tolerate approximately 500 mite-days before reductions in fruit yield or quality occur. Therefore, one goal of any mite monitoring program is to ensure that miticide treatments are recommended so as to prevent 500 mite-days from occurring. Another goal of a mite monitoring program is to allow biological control to take its course when mite natural enemies (phytoseiid mites) are present. So, a mite monitoring program should not recommend intervention with pesticides when treatments are not necessary. A final goal of a mite monitoring program is to indicate when the pest population should again be sampled to determine its status. If, at the time of sampling, mite densities are very low, then it is not necessary to sample the population again in a short period of time. On the other hand, if densities are currently close to but not greater than a treatment threshold, the population should

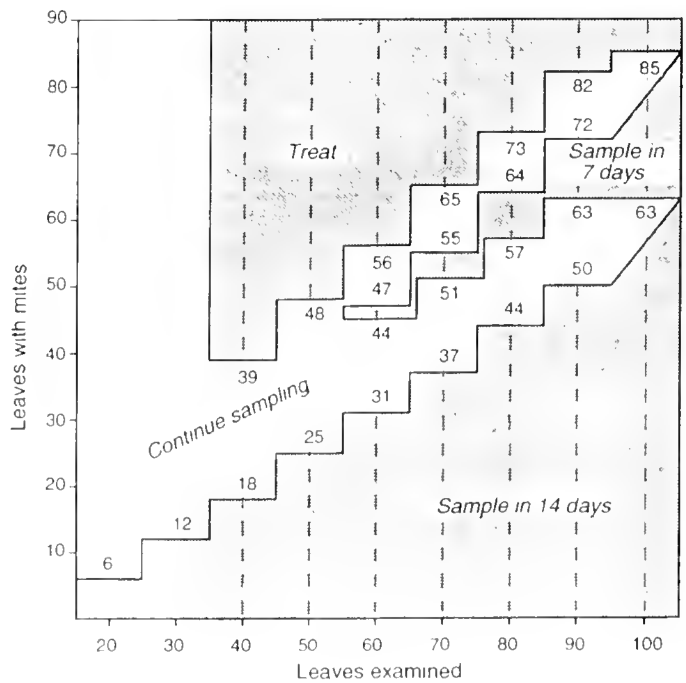
Use this sampling guide during June



Use this sampling guide during July



Use this sampling guide during August



be assessed again in a short period of time. The monitoring program described here meets these goals.

This monitoring procedure classifies ERM density into one of three categories: 1) greater than treatment threshold, indicating application of a miticide is necessary, 2) less than treatment threshold, but requiring assessment again in about 7 days, and 3) much less than a treatment threshold and not requiring assessment again for 14 days.

ERM are small and often numerous. This makes counting these pests a tedious and often difficult task. For monitoring purposes, it is only necessary to record the number of leaves infested with one or more motile mites. A mathematical relationship between the proportion of infested leaves and actual density can then be used to classify mite density. Because higher mite numbers can be tolerated as the season progresses, three sampling procedures are used at different times of the growing season; one each for June, July, and August with treatment thresholds of 2.5, 5, and 7.5 mites per leaf , respectively.

The sampling guides are used as follows:

1. Sampling trees from throughout the orchard block, collect five intermediate aged leaves from each of four trees. To make sure the leaves are of an intermediate age, pick them from the middle of the fruit cluster before July and from the middle of fruit clusters or terminals thereafter.

2. Using a magnifier, examine the top and bottom surface of each leaf for motile mites (anything but eggs), and keep track of the number of leaves with mites on them.

3. When all 20 leaves have been examined, compare this number with the numbers on the decision guide. When the counts fall into any of the shaded regions, sampling is terminated and a decision to either "Treat", "Sample in 7 days," or "Sample in 14 days" is made. If the counts fall in the region labeled "Continue sampling" collect and examine groups of 10 leaves until the counts fall into one of the shaded regions. If the number of leaves with mites is equal to the values on the guide, use the decision indicated by the value minus one (e.g., for the June chart, if 18 leaves have ERM after examining 20 leaves, use 17 leaves with mites and make a decision to "Continue sampling").

* * * * *

Establishment and Spread of Released *Typhlodromus pyri* Predator Mites in Apple Orchard Blocks of Different Tree Size: 1998 Results

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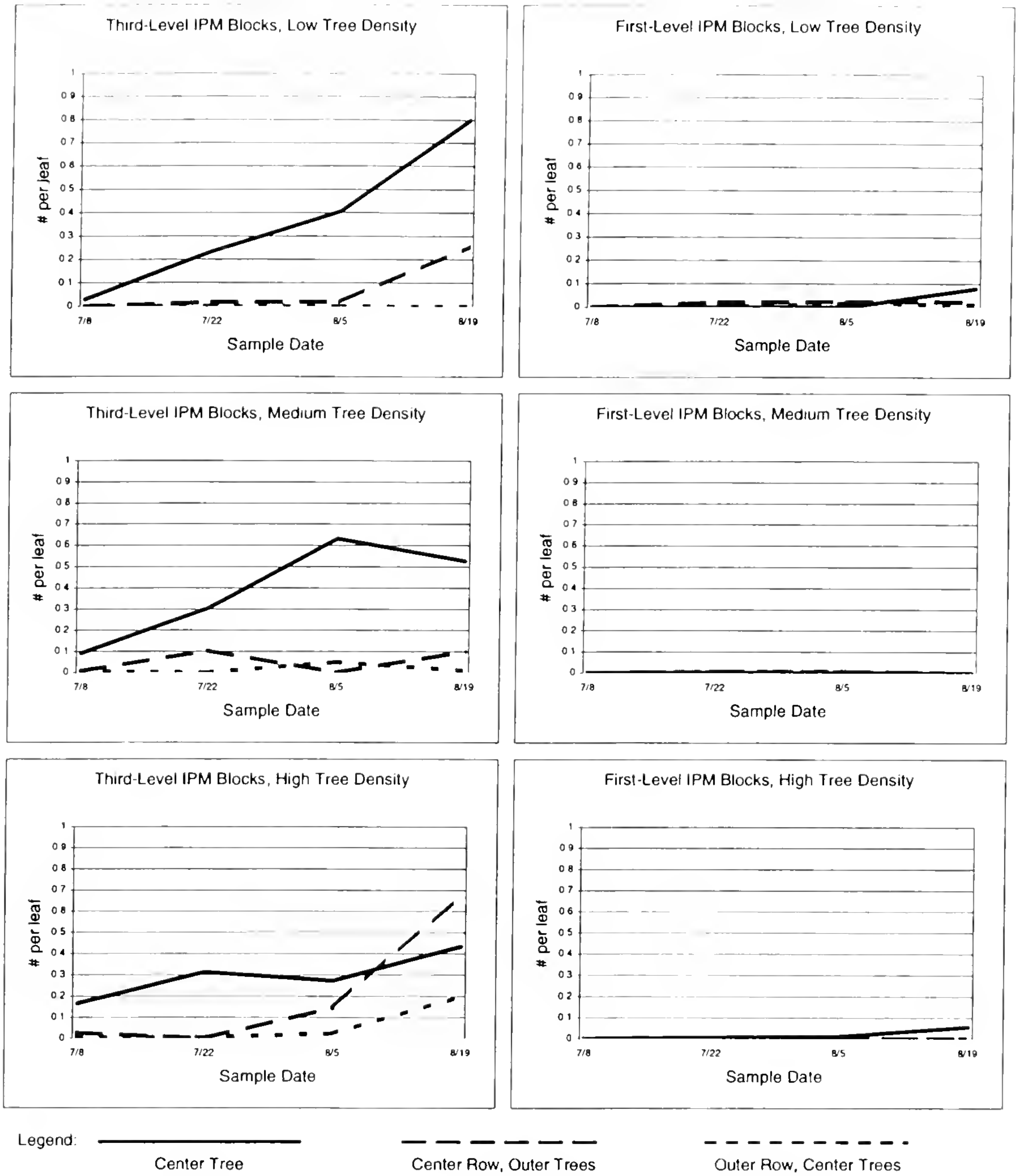
Studies in New York, other states, and other countries have shown that the predatory mite *Typhlodromus pyri*, where established, can be highly effective in providing season-long suppression of pest European red mites in commercial apple orchards. Three of the reasons why *T. pyri* is more reliable than the mite predator *Amblyseius fallacis* in maintaining pest mites below injurious levels year after year are its better ability to endure cold winter temperatures, its better ability to withstand low relative humidity, and its better ability to survive periods of short supply of pest mites as food (as may occur in springtime). In Massachusetts, *A. fallacis* has been found present in about 90% of commercial apple orchards sampled since 1978. In contrast, *T. pyri* has been found present in numbers large enough to be detected in fewer than 10% of Massachusetts commercial apple orchards sampled since 1978.

In 1997, we initiated a program of introducing *T. pyri* into eight commercial apple orchards in Massachusetts in which it was not previously detected. Three of our aims were to (1) chart the degree of establishment of *T. pyri* in each orchard as affected by types of pesticide used; (2) chart the rate at which *T. pyri* spread from trees on which they were released to other trees in the same orchard blocks, as affected by tree size and planting density; and (3) determine the impact of *T. pyri* on pest mite populations. Our study was intended to extend over a period of at least 3 years. In the Fall 1997 issue of *Fruit Notes*, we reported on our findings from 1997, the first year. Here, we report on our findings from 1998, the second year.

Materials & Methods

As indicated in the Fall 1997 issue of *Fruit Notes*, our experiment was conducted in six blocks of apple trees in each of eight commercial orchards. Of the six blocks per orchard, two each contained trees on M.9, M.26, or M.7 rootstock, designated as small, medium-size, or large trees. One block of each pair received first-level IPM practices, wherein growers applied insecticides and fungicides of their own choosing and timing of application, which extended from April through August. The other block of each pair received third-level IPM practices, wherein the initial intent was that no pesticides known to cause a moderate or high level of harm to *T. pyri* were to be used. These included synthetic pyrethroid insecticides (at any time) and EBDC fungicides (after mid-June). In addition, after mid-June, no insecticides of any type was to be used, and captan or benomyl were the only fungicides to be used. There was no restriction on type of miticide allowable for use in third-level blocks, except for Carzol, which was not used. Each block was comprised of 49 trees (7 rows of 7 trees per row) and of the cultivars McIntosh, Empire and Cortland. Third-level IPM is similar to second-level IPM in focus on using biologically-

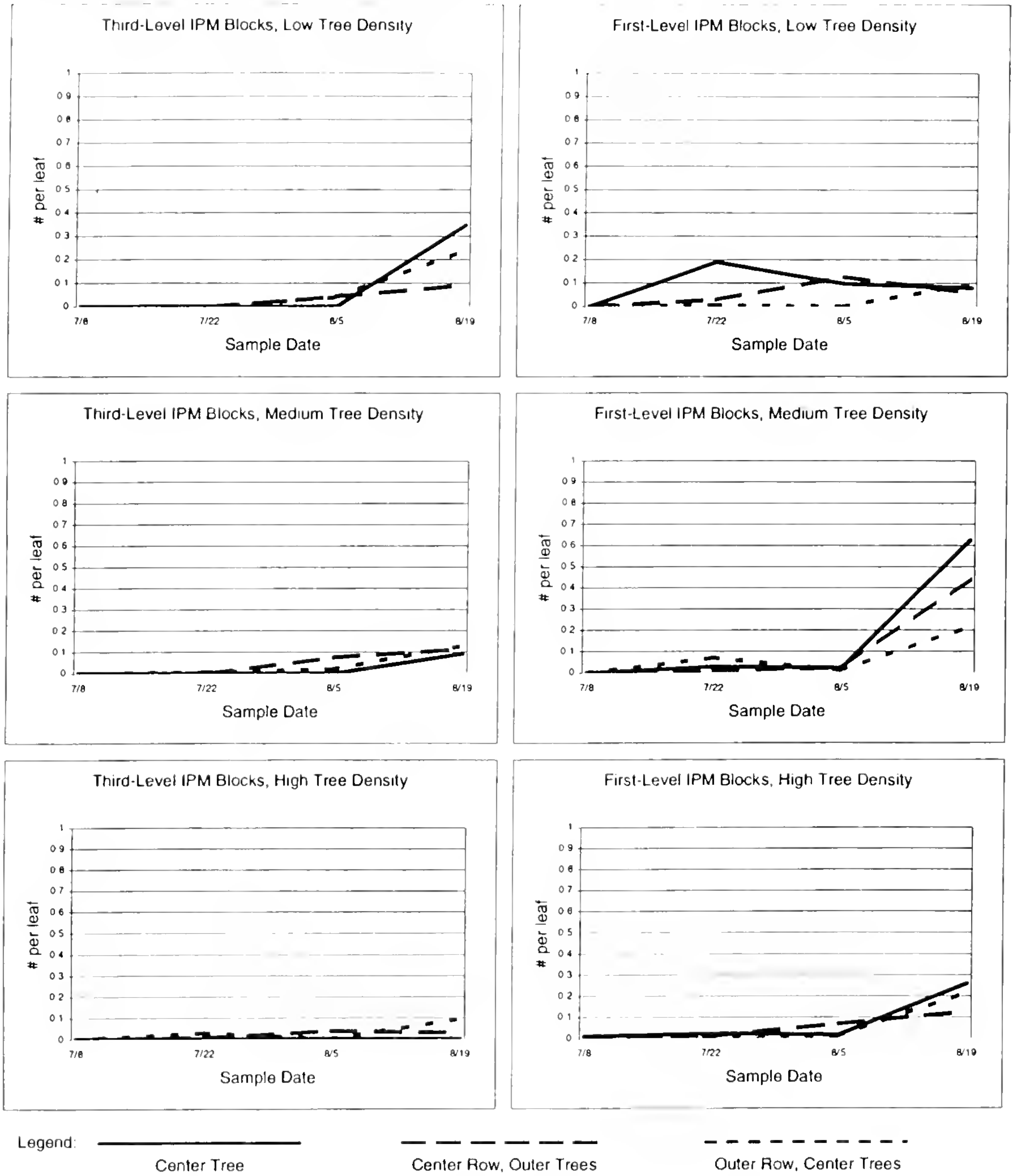
Figure 1. In July and August of 1998, abundance of ***T. pyri*** mite predators on leaves sampled from third-level IPM blocks (in which *T. pyri* were released on the **center tree** in mid-May 1997) and first-level IPM blocks (in which no releases of *T. pyri* were made).



based pest management practices, but it embraces integration with horticultural concerns (such as tree size) as an added component.

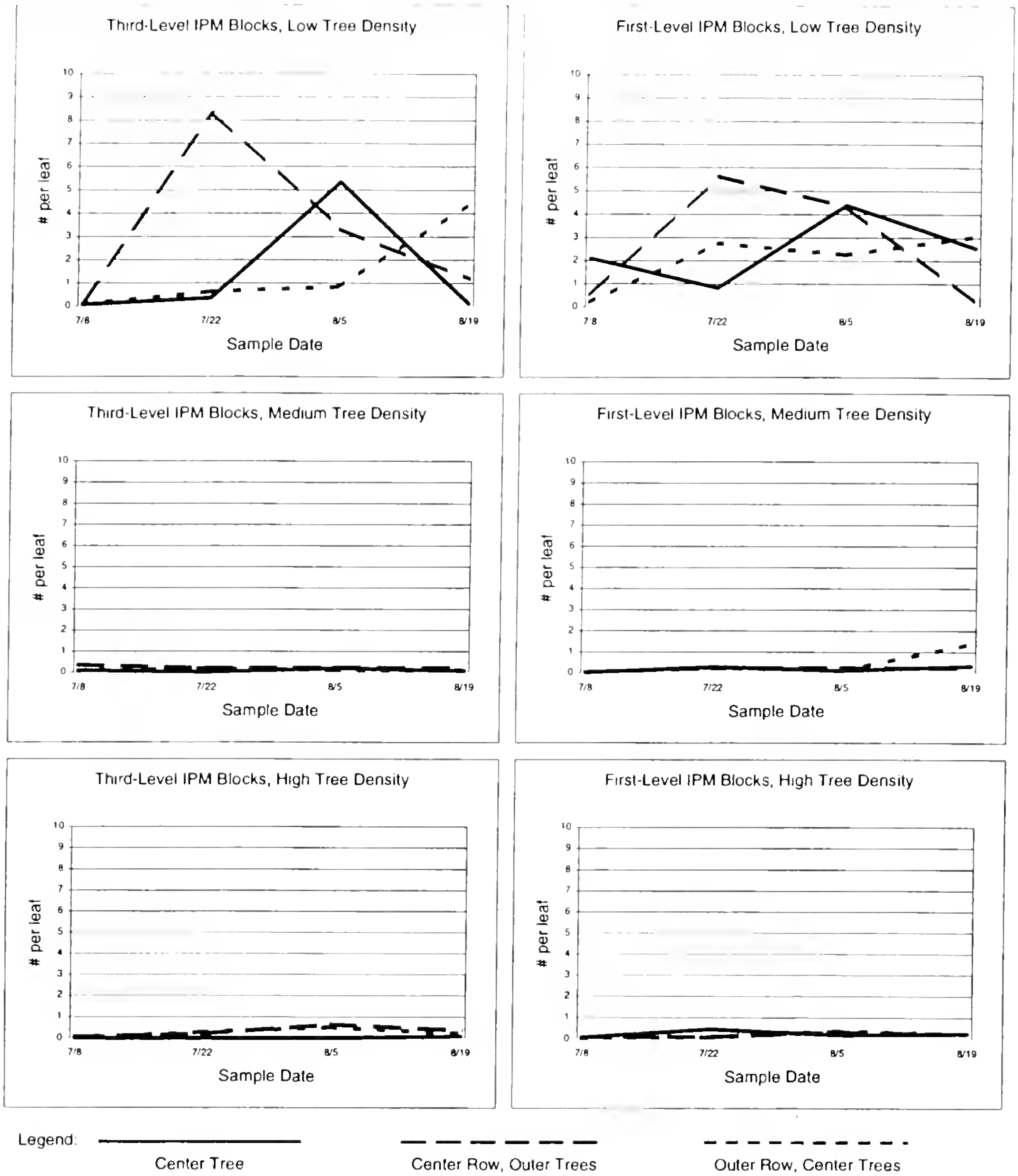
T. pyri were released onto the center tree of each third-level IPM block in May of 1997, in the manner described in the Fall 1997 issue of *Fruit Notes*. No *T. pyri* were released in first-level IPM blocks. Three times during the summer of 1997 and four times during the summer of 1998 in each of the 48 blocks, we sampled 25 leaves from the

Figure 2. In July and August of 1998, abundance of ***A. fallacis*** mite predators on leaves sampled from third-level IPM blocks (in which *T. pyri* were released on the **center tree** in mid-May 1997) and first-level IPM blocks (in which no releases of *T. pyri* were made).



center tree, 15 leaves from each of the two outermost trees in the center row, and 15 leaves each from the center tree in each of the two outermost rows. The leaves were sent by overnight mail to Geneva, New York for the identification and counting of pest and predatory mites. In all, more than 12,000 leaves were sampled in 1997 and more than 16,000 in 1998.

Figure 3. In July and August of 1998, abundance of **European red mites** on leaves sampled from third-level IPM blocks (in which *T. pyri* were released on the **center tree** in mid-May 1997) and first-level IPM blocks (in which no releases of *T. pyri* were made).



Results

As shown in Figure 1, *T. pyri* were found in low but detectable average numbers in early July of 1998 on center trees in which they were released in third-level IPM blocks in 1997. Populations on center trees in early July averaged greatest on small (high density) trees, middle range on middle-size (middle density) trees, and least on large (low density) trees. By the latter part of August, *T. pyri* on

center trees reached 0.4, 0.5, and 0.8 per leaf on small, middle-size, and large trees, respectively. At this time, *T. pyri* on the two outermost trees of the center row averaged 0.8, 0.1, and 0.3 per leaf on small, middle-size, and large trees, respectively, indicating spread of *T. pyri* up and down the same row in which they were released, particularly in blocks of small trees. There was little or no detectable spread of *T. pyri* onto center trees of the outermost rows of blocks of medium-size and large trees but detectable spread onto such trees in blocks of small trees. In 1998, *T. pyri* were largely absent or at most present in extremely low numbers in first-level IPM blocks in which they were not released in 1997 (Figure 1).

As shown in Figure 2, by the latter part of August of 1998, *A. fallacis* had built to larger populations in first-level than in third-level IPM blocks of both small and medium-size trees, although the reverse was true in blocks of large trees. In contrast to *T. pyri*, which was detectable in third-level blocks of all tree sizes in early July, *A. fallacis* was not detectable in any blocks (either third- or first-level IPM) until the latter part of July.

As shown in Figure 3, populations of European red mites in 1998 were barely detectable during July and August in either third- or first-level IPM blocks of small or medium-size trees. They did, however, reach substantial (though not damaging) average numbers in both third- and first-level blocks of large trees.

Table 1 provides information on the possible influence of both type of pesticide used and abundance of European red mites as prey on population levels of *T. pyri* in third-level IPM blocks. It appears that abundance of European red mites had less of an influence on buildup of *T. pyri* than did type of pesticide used. For example, in Orchard A, latter-August populations of *T. pyri* in 1998 averaged nearly double those of 1997, whereas in Orchard H, latter-August populations in 1998 averaged less than one-fourth those of 1997. Latter-August populations of European red mites in 1998 averaged the same in both of these orchards. No insecticide harmful to *T. pyri* was applied in third-level IPM blocks in either Orchard A or Orchard H in 1997 or 1998. In 1997, neither orchard received any EBDC fungicide or Agri-Mek as a miticide. In 1998, Orchard H received three applications of EBDC fungicide and one application of Agri-Mek, as opposed to use of only one application of EBDC fungicide and no Agri-Mek in Orchard A. These combined data suggest that either the greater number of EBDC applications or the use of Agri-Mek was responsible for the rather sharp decline of *T. pyri* in 1998 in Orchard H.

Data from other orchards (Table 1) support the lack of strong influence of abundance of European red mites on extent of *T. pyri* buildup or decline from 1997 to 1998 (compare Orchard D with Orchard A) and the lack of strong influence of number of applications of EBDC fungicides (compare Orchard H with Orchard B, and Orchard E with Orchard A). Instead, it appears that use of Agri-Mek in third-level IPM blocks was the principal factor responsible for the decline in abundance of *T. pyri* from 1997 to 1998 in third-level blocks in some orchards (compare Orchards D, E, G, and H, all of which experienced a decline by an average amount of about 75% in *T. pyri* from 1997 to 1998 and all of which received Agri-Mek in 1998, with Orchards A, B, C, and F, all of which experienced an increase in *T. pyri* by an average amount of about 240% from 1997 to 1998 and none of which received Agri-Mek in 1998).

Conclusions

Combined data from 1997 (reported in the Fall 1997 issue of *Fruit Notes*) and 1998 (reported here) indicate that *T. pyri* mite predators released in 1997 became firmly established and proliferated in 1998 in those third-level IPM blocks that in 1998 did not receive Agri-Mek as a miticide. Our evidence suggests that abundance of European red mites as prey of *T. pyri* was a less important factor affecting population increases or decreases of *T. pyri* than was the effect of Agri-Mek per se on *T. pyri*. Our findings also indicate that by the end of 1998, *T. pyri* had spread at least as far as three trees up- and down-row from the tree in which it was released in 1997, particularly so in blocks of small (high density) trees where intra-row tree foliage was rather contiguous. Spread to third rows on either side of the row in which *T. pyri* were released in 1997 was only slight in blocks of small trees and essentially nil in blocks of medium-size and large trees in 1998.

Table 1. Mean numbers of *T. pyri* and European red mites (ERM) per leaf in late August and pesticides used in third-level IPM blocks in eight commercial apple orchards in Massachusetts in 1998 where *T. pyri* were released in May of 1997.

	Mean no. per leaf*			Miticide used		No. EBDC** fungicide applications		No. insecticide*** applications	
	T. pyri		ERM						
Orchard	1997	1998	1998	1997	1998	1997	1998	1997	1998
A	1.02	1.93	0.03	Oil	Oil	0	1	0	0
B	0.92	1.74	3.92	Oil	Savey	3	3	0	1
C	0.08	1.03	0.09	Oil	Oil	0	0	0	0
D	0.67	0.41	0.05	Savey	Agri-Mek	0	2	0	0
E	1.09	0.33	0.00	Savey	Agri-Mek	0	1	0	0
F	0.03	0.16	0.31	Agri-Mek	Pyramite	0	1	0	0
G	1.41	0.13	0.01	Savey	Agri-Mek	0	2	0	0
H	0.38	0.09	0.03	Pyramite	Agri-Mek	0	3	0	0

* Averaged across all three sizes of trees sampled.
** Application through mid-June, none thereafter.
*** Includes only insecticides known to be moderately or very harmful to *T. pyri*: synthetic pyrethroids, oxamyl, methomyl and chlorpyrifos.

We are encouraged by these findings and plan to continue our study of the extent of establishment and spread of *T. pyri* in these same third-level IPM blocks in 1999. At the same time, we find it sobering that the rate of spread of *T. pyri* into non-release trees is apparently quite modest and that certain pesticides that were believed to be no more than moderately harmful to *T. pyri* (e.g. Agri-Mek) may in fact be very harmful.

Acknowledgments

We are grateful to the eight growers participating in this experiment and who made special effort to apply pesticide selectively to third-level IPM blocks: Bill Broderick, Dave Chandler, Dana Clark, Dave Shearer, Joe Sincuk, Tim Smith, and Mo Tougas. This work was supported by State/Federal IPM funds.

Budagovsky 9: A Summary of Fifteen Years of Trial

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New rootstocks are becoming available every year, some from breeding programs in the United States and others from a wide range of different countries. Before commercial plantings of these rootstocks begin, it is necessary to conduct trials to understand all of the potential values of and problems with these rootstocks. Mark is an example of a rootstock that was planted widely before adequate testing had occurred. It was first planted in a large-scale test only six years before widespread commercial planting began. Problems with Mark started to appear in research trials just a few years later, after many trees were already in the ground. Hindsight suggests that waiting a few more years would have been prudent, but the release and promotion of new rootstocks before we truly understand them likely will continue to occur.

Significant quantities of data have been collected on rootstocks that were released or brought into the U.S. in the 1970's and 1980's. This collection of rootstocks, not those that are just being released, should form the list of alternatives to the well known Malling and Malling-Merton series. A few of these rootstocks will be discussed in upcoming issues of *Fruit Notes*. In this issue, Budagovsky 9 is the focus.

In 1974, Jim Cummins and Dick Norton described Budagovsky 9 (B.9) as "the most promising candidate to replace M.9." B.9 was released from the Michurin College of Horticulture in central Russia, having been selected from a cross of M.8 and 'Red Standard.' In many respects, it was considered very similar to M.9; however, it was more cold hardy and more resistant to collar rot (Ferree, D.C. and R.F. Carlson. 1987. Apple rootstocks. In: Rootstocks for Fruit Crops. John Wiley & Son, New York).

In Massachusetts, the first planting including B.9 was part of an NC-140-coordinated trial established in 1984. This trial included 15 rootstocks with Starkspur Supreme Delicious as the scion cultivar. Since then, additional trials including B.9 were established in 1990, 1994, 1995, and 1997 with Marshall McIntosh, Golden Delicious, Jonagold, Empire, Rome, Gala, Cortland, Rogers McIntosh, Pioneer Mac, Ginger Gold, Fortune, and Honeycrisp as scion cultivars. This article will provide data from all but the most recent plantings, extracting data from each experiment to compare B.9 with M.9 and/or M.26. These data are given in Table 1.

In general B.9 produced a tree similar in size to M.9, possibly slightly smaller than those on M.9 EMLA and slightly larger than those on M.9 (dirty 9). The trunk cross-sectional area of trees on B.9 was on average 50% (40 and 75% range) of that of trees on M.26.

Rootstock did not affect yield per tree significantly. Efficiency, however, was dramatically affected by rootstock. M.9 and B.9 resulted in similar efficiency, but they were about 50% more efficient than trees on M.26. The practical result of this difference in efficiency is that trees on M.9 or B.9 will yield more per acre than those on M.26.

B.9, M.9, and M.26 all resulted in good fruit size, and there were no consistent differences among the three rootstocks. Overall, average fruit size in these studies averaged about 200 g (96 count), attesting to the fact that these dwarfing rootstocks regularly result in large fruit, even with a lack of irrigation, as was the case in all of the trials.

Other data not shown here suggested that B.9 results in a similar timing of fruit ripening and similar fruit quality to those from trees on M.9.

In conclusion, 15 years of study show B.9 to be a good apple rootstock. Performance in Massachusetts, however, does not suggest that B.9

Table 1. Characteristics of trees of various cultivars on B.9 in comparison to M.9 and M.26. These data were extracted from several replicated trials, and in most cases, represent conditions through the end of the 1998 growing season (Delicious data, however, were collected through the end of the 1993 season). Fruit size is the average over all fruiting years for each trial.

Tree age (years)	Cultivar	Rootstock	Trunk cross-sectional area (in^2)	Cumulative yield per tree (bu)	Cumulative yield efficiency (lbs/in^2 TCA)	Fruit size (no./42-lb box)
10	Delicious	B.9	3.9	7.3	78	84
		M.26 EMLA	6.4	9.1	63	83
9	Marshall McIntosh	M.9 EMLA	5.6	6.1	13	112
		B.9	4.0	5.4	17	111
		M.26 EMLA	10.9	6.3	7	127
	Golden Delicious	M.9 EMLA	5.7	5.1	37	101
		B.9	5.7	5.4	40	99
		M.26 EMLA	7.4	5.8	34	96
	Jonagold	M.9 EMLA	5.6	6.3	47	71
		B.9	6.4	6.4	41	75
		M.26 EMLA	11.8	7.8	29	73
	Empire	M.9 EMLA	5.1	7.1	57	101
		B.9	4.5	5.6	56	103
		M.26 EMLA	9.5	5.2	24	106
	Rome	M.9 EMLA	8.5	9.8	48	75
		B.9	5.4	7.4	58	79
		M.26 EMLA	8.8	8.6	41	71
5	Gala	M.9 EMLA	3.9	1.8	20	110
		B.9	2.9	1.7	26	120
		M.26 EMLA	5.9	1.9	16	120
4	Cortland	M.9	1.2	0.2	7	88
		B.9	1.4	0.4	10	90
	Rogers McIntosh	M.9	1.6	0.3	10	101
		B.9	1.7	0.2	4	121
	Pioneer Mac	M.9	1.1	0.3	9	108
		B.9	1.7	0.2	4	127
	Ginger Gold	M.9 T337	1.1	0.3	13	80
		B.9	1.1	0.3	13	80

is a better rootstock than M.9. However, northern apple-growing regions where winter damage may be a problem and in blocks where collar rot may be a problem, growers may see better performance from B.9 than M.9.

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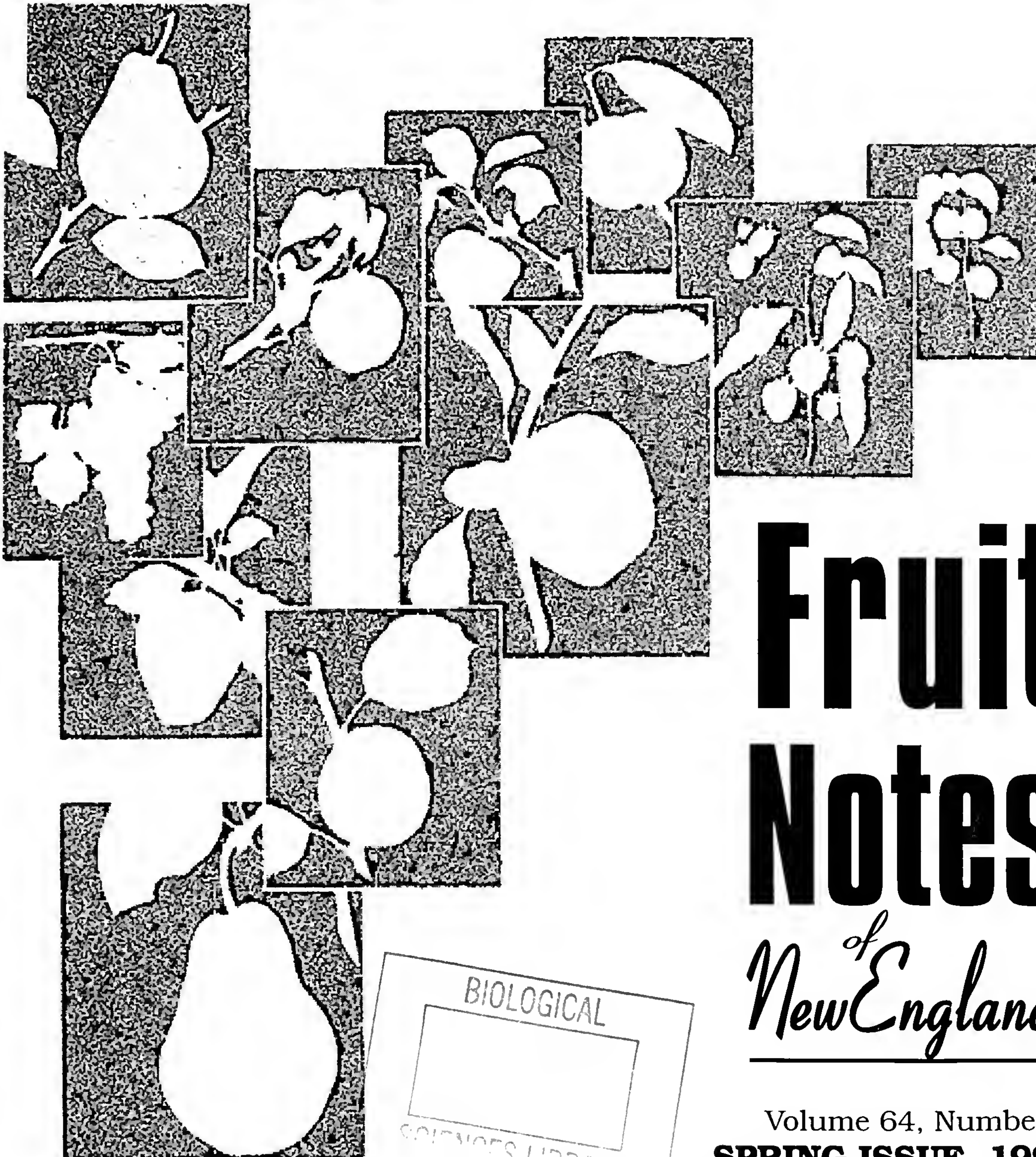

Fruit Notes of New England

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Characteristics of Scald Susceptibility and Development on Cortland Apples in New England

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Postharvest development of scald is a severe threat for certain cultivars of apples. Cortland is particularly susceptible, so much so that growers would likely have discontinued production except for the discovery that scald could be controlled by treatment with diphenylamine (DPA). Even today, however, Cortland fruit stored long-term carry a significant risk of scald development.

In the Spring 1998 issue of *FruitNotes,* we reported on the success we have had in predicting scald susceptibility of New England Delicious apples, using equations based on harvest date, preharvest temperature, and harvest starch score of the fruit. At the same time that we have been studying scald prediction for Delicious, we have also been attempting to develop a similar prediction system for Cortland. For reasons we are unable to explain, we have failed in these efforts with Cortland. However, during our experiments we have learned much about scald development on this cultivar, and here we report some of these findings that

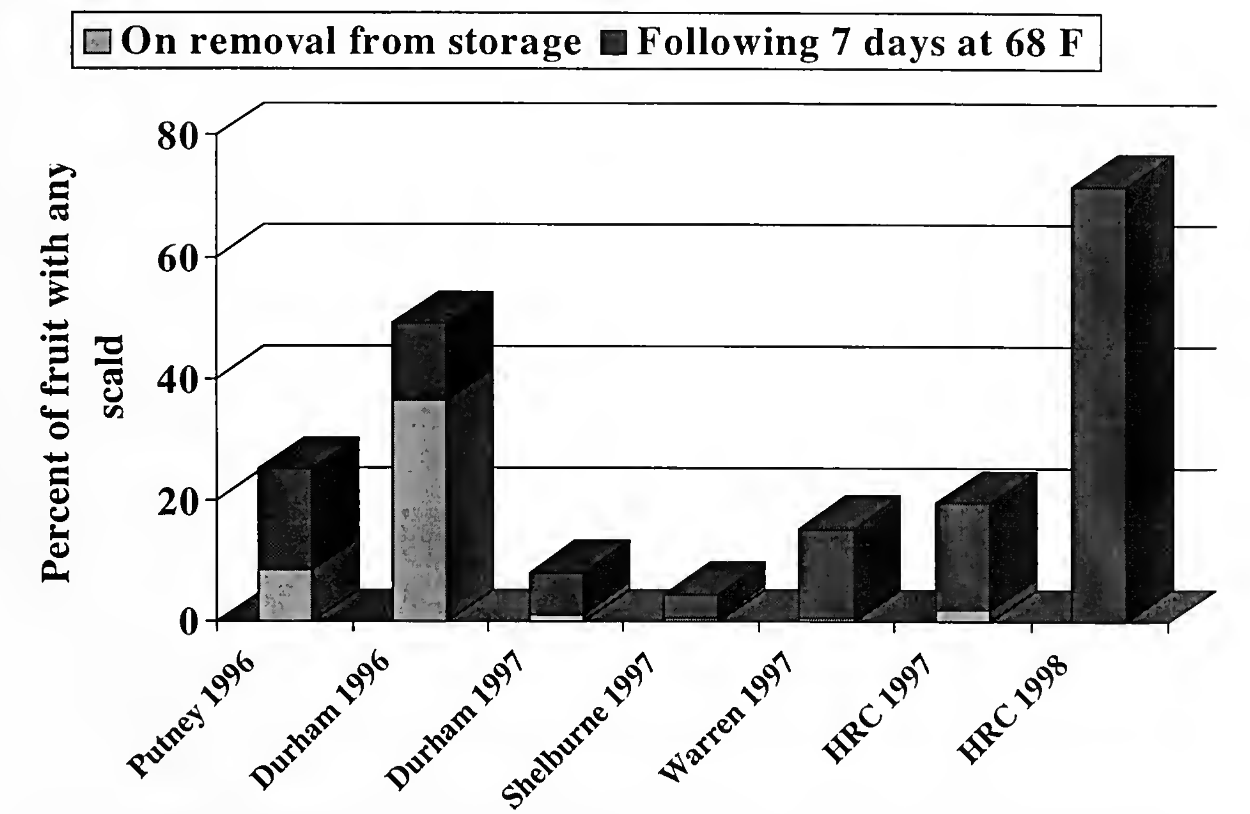


Figure 1. Scald development following 20 weeks of 32°F air storage of Cortland apples (harvest dates vary).

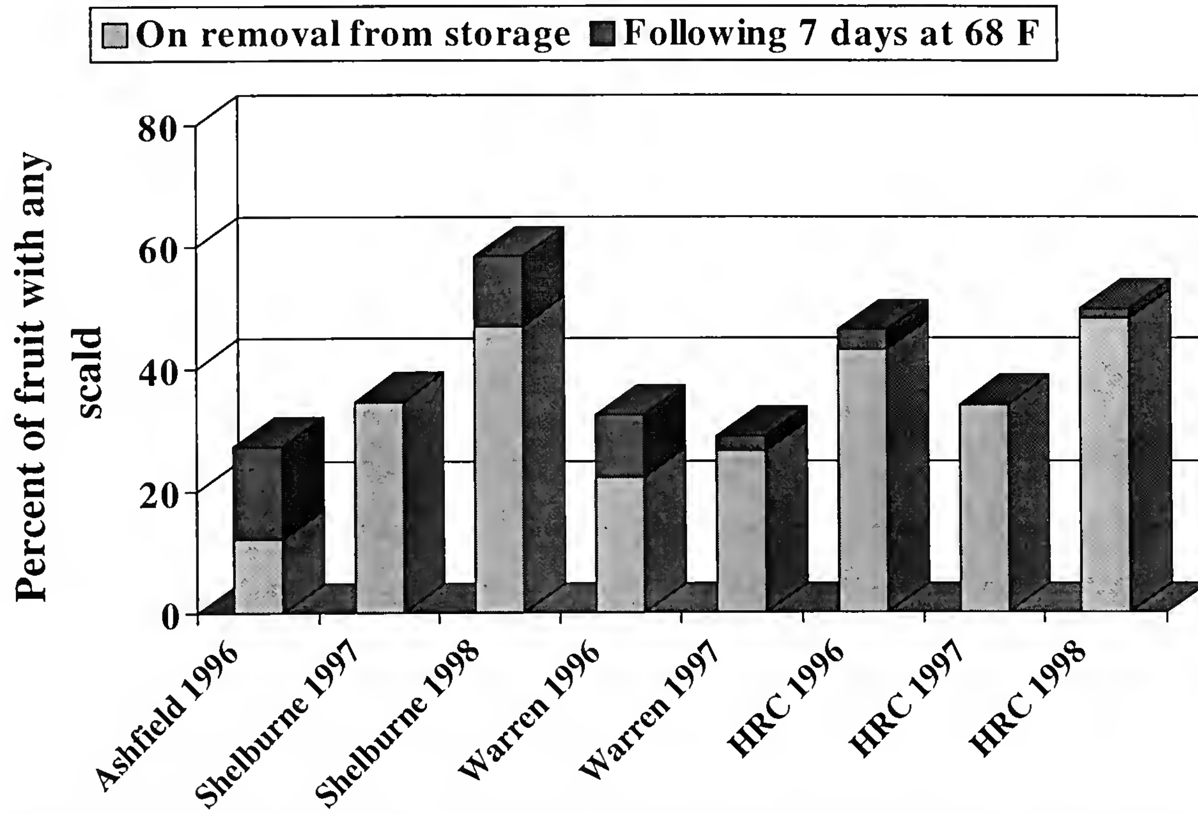


Figure 2. Scald development following 25 weeks of 32°F air storage of Delicious apples (harvest dates vary).

lead us to a set of conclusions about the current state of knowledge regarding scald development and control for New England-grown Cortland apples.

In our studies, we collected Cortland apples from 1985 through 1998 at the Horticultural Research Center (HRC), Belchertown, MA. In addition, samples were collected from other sites: Shelburne and Warren, MA (1997), Putney, VT (1996), Durham, NH (1995, 1996, and 1997), Storrs, CT (1995), and Monmouth, ME (1996). Each sampling site provided at least two harvests per year indicated. Fruit were stored at 32°F in air for 20 weeks, and then kept at 68°F for one week, after which scald development was evaluated. (In some years, scald was evaluated both at removal from storage and again after one week at 68°F.) All fruit were standard Cortland, i.e. no red sports were used. Fruit were not treated with DPA.

Cortland and Delicious differ in a very important way in the manner in which they develop scald. Figure 1 shows the presence of scald immediately upon removal from storage and then again after one week at room temperature. In most cases, little or no scald was present when the Cortlands were removed from storage, but it was present, sometimes extensively, after the fruit had been warmed. In contrast, Figure 2 illustrates the performance of Delicious. On these fruit, most scald was present at removal from storage, with only slight increases at room temperature. This means that Cortlands are very deceptive. They may look scald-free at the time of packing but become badly scalded once they warm up. Delicious, on the other hand, do not present this problem. A trip to the supermarket can be instructive. Rarely will you find a scalded Delicious on display, but scalded Cortlands are a common occurrence. Scalded Delicious usually can be removed during packing, but many Cortlands scald after packing.

For a scald prediction system to be of value, you must have considerable variation in scald development on samples. You can see in Figure 1 that this was the case in our experiments. Some samples developed hardly any scald while others developed a great deal of it. What are the sources of scald variation in Cortland?

In Figure 3 you see year-to-year variation in scald

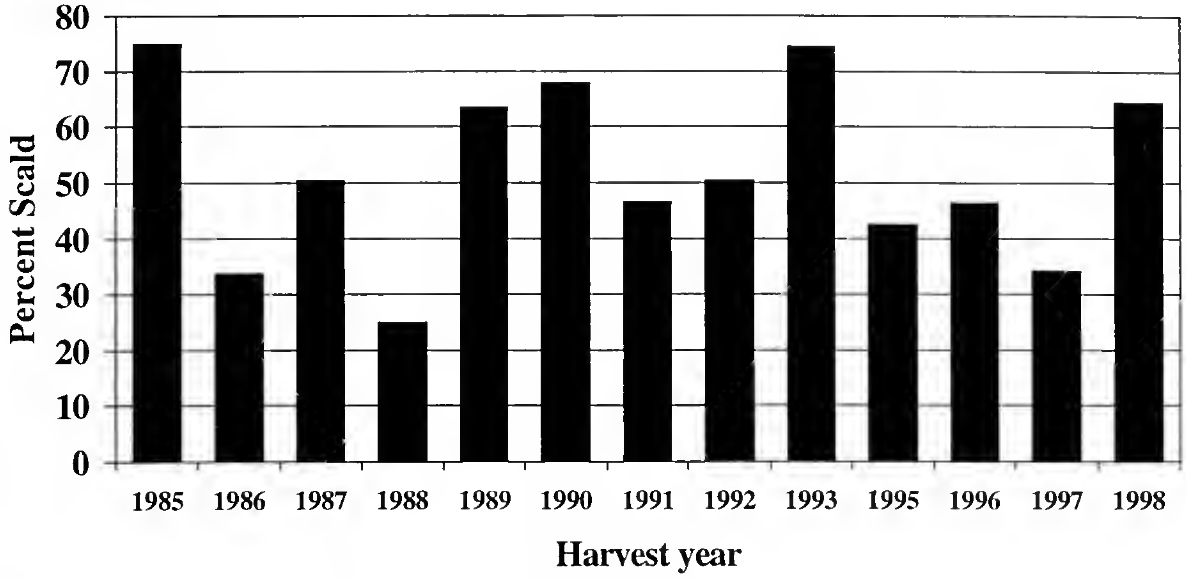


Figure 3. Year-to-year variation in mean scald development on HRC-grown Cortland apples (means corrected to account for differences in harvest dates each year).

susceptibility of Cortland apples from the HRC in Belchertown, MA. Scald always occurred, but it was much worse in some years (e.g. 1985 and 1993) than in others (e.g. 1988 and 1997). Thus, some years were "bad scald years" while others were not, although no year was scald-free.

In Figure 4, you see orchard-to-orchard variation in Cortland scald development in New England. No particular pattern is evident, except that 1997 seems to have produced less scald than 1995 or 1996. Even this difference may be confounded by the fact that the 1997 samples were harvested on average 3 days later than the 1996 samples, but with an average starch score of 3.6 in 1997 vs 3.8 in 1996 (i.e. fruit were harvested slightly later, but slightly less ripe in 1997) . That the fruit from Monmouth, ME did not develop more scald than they did seems remarkable, since those samples were exposed to less cool weather (8 days of sub50°F before harvest for ME vs overall mean of 17 days) than were any other group of samples, had the lowest starch scores (ME mean of 2.5 vs overall mean of 3.9), and were among the earliest harvested (ME mean of September 27 vs. overall mean of October 3). All those factors generally are considered "scald enhancing."

Time of harvest is a major factor in scald susceptibility of apples, and it is certainly a factor for Cortland. Figure 5 presents a composite of scald development on all of our samples, across years and sites, based on harvest date of the fruit. Cortlands picked before September 21 were extremely scald susceptible, while those picked after October 20 developed almost no scald, regardless of year or growing site. Between these extremes, susceptibility gradually fell as harvest date was later. However, delaying harvest until fruit have low susceptibility clearly is not desirable. Not only do they become excessively soft, but they also become susceptible to senescent breakdown, which occurred in 30% of fruit harvested after October 15.

Since there is so much variation in Cortland scald susceptibility, an effective method of predicting poststorage scald development at the time of harvest could be very useful in guiding strategies to control scald, e.g. whether or not to apply DPA, and , if so, what concentration to use. However, none of the equations we have created to relate preharvest conditions, such as we described for Delicious in the Spring 1998 issue of *FruitNotes*, have given reliable results in separating lots of fruit by their relative scald susceptibility. In Figure 6 are presented 10 years of results from the HRC, comparing percent scald "predicted" (in hindsight) from harvest date, starch score, and number of preharvest sub 50°F days to

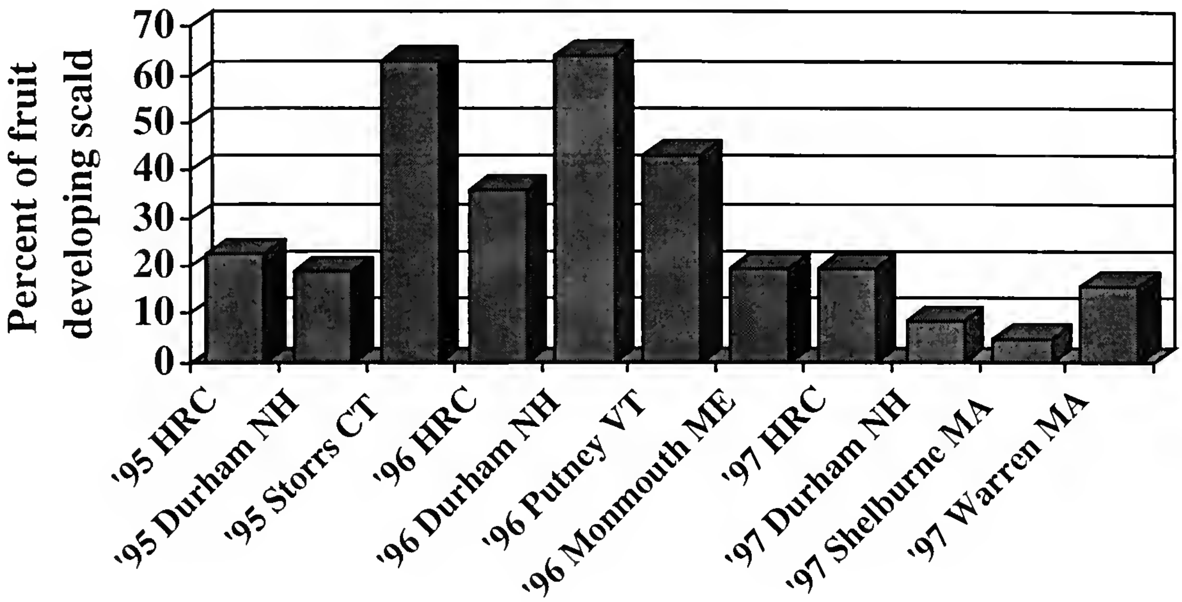


Figure 4. Orchard-to-orchard variation in scald susceptibility of Cortland apples in 1995, 1996, and 1997.

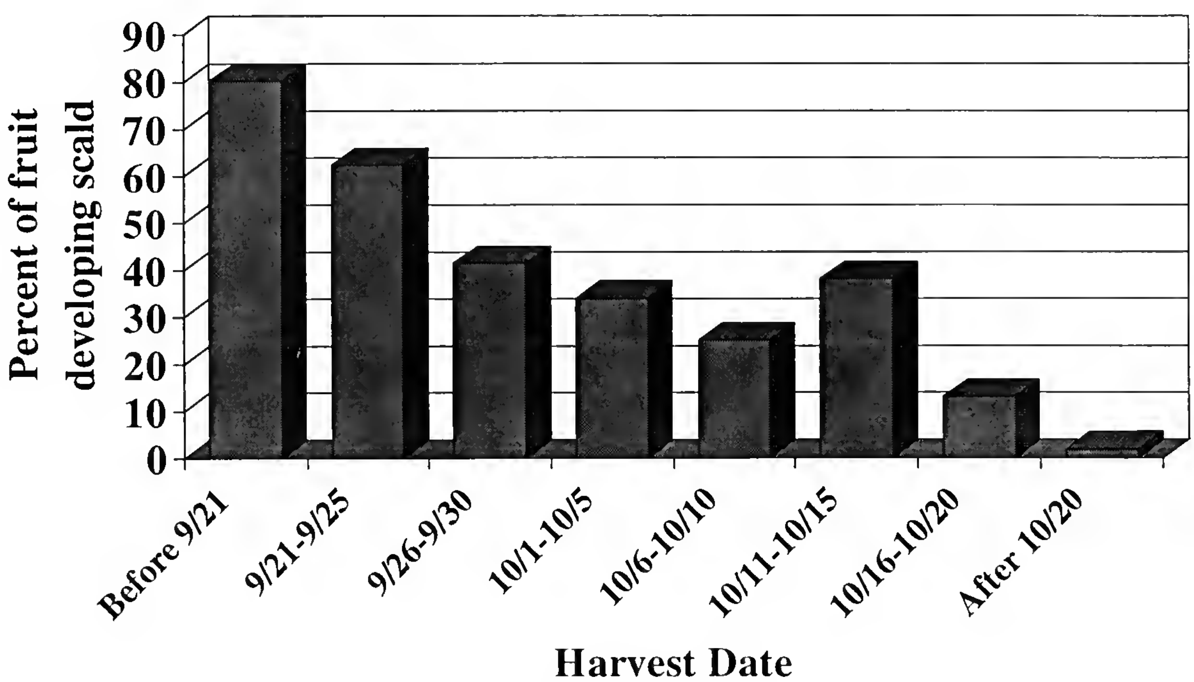
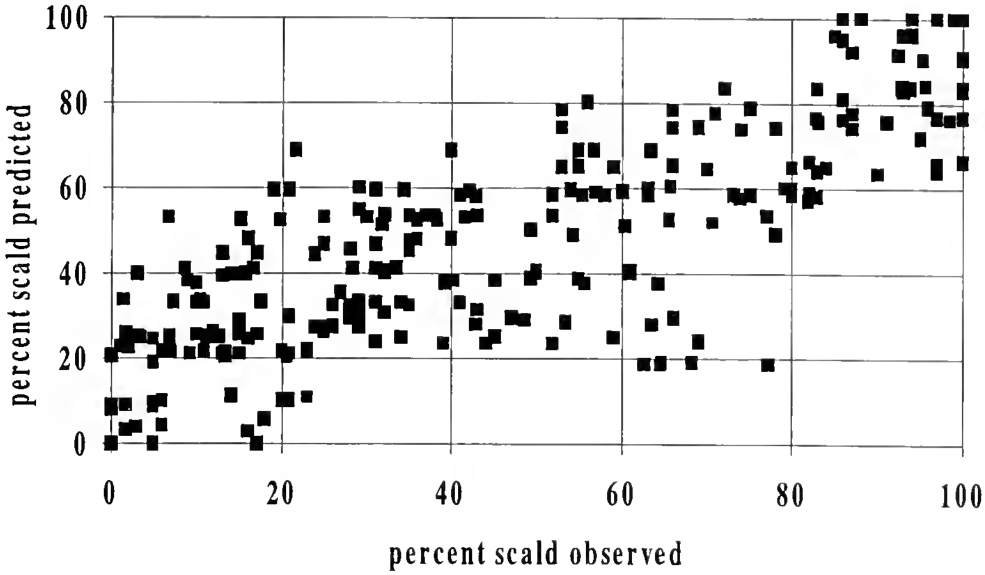


Figure 5. Effect of harvest date on poststorage scald development on NE-grown Cortland apples; 506 samples, 1985-98.



% scald = 116.8 - 1.43*(harvest date where 9/1=1) - 1.20*(n of preharvest days<50) - 1.58*(harvest starch)

Figure 6. HRC generated equation showing predicted vs. actual scald on HRC Cortland apples 1988-1997.

actual percent scald observed. While the trend of the data seems encouraging, the reliability of the predictions is not acceptable. Furthermore, this equation gave much worse results when applied to fruit harvested from other orchards in new England. We are continuing to pursue an effective predictive system, but as of now, we have not produced a tool in which we have confidence.

Based on nearly 15 years of experiments with Cortland, we draw the following conclusions about scald susceptibility of this cultivar in New England:

1. Scald susceptibility varies enormously from site to site, and also from year to year within a site. Because your fruit did or did not scald last year is not a reliable index of what they will do this year.
2. Susceptibility declines as fruit mature and, to some extent, as they experience increasing exposure to temperature below 50°F before harvest. However, delaying harvest to obtain scald resistance can result in soft fruit that develop senescent breakdown.
3. We still cannot predict scald development on Cortland.
4. At this time DPA is the only reliable method of controlling scald on Cortland. Unlike with Delicious, we have not been able to predict the concentrations needed to control Cortland scald.
5. Because Cortlands are scald-free at removal from storage does not mean they will remain scald-free when they warm to room temperature. Most scald symptoms develop after storage of this cultivar. Effective scald control treatment at harvest time is your best assurance that Cortlands will remain scald-free during their shelf life.

We wish to express sincere thanks to the following people who contributed greatly to this work by providing samples of fruit for study: Mr. Joseph Sincuk, HRC, Belchertown, MA, Mr. Dana Clark, Clark Orchards, Ashfield, MA, Mr. Evan Darrow, Green Mountain Orchards, Putney, VT, Mr. Timothy Smith, Apex Orchards, Shelburne, MA, Mr. Mark Tuttle & Mr. Robert Tuttle, Breezelands Orchards, Warren, MA, Professor William G. Lord, University of New Hampshire, Dr. James Schupp, University of Maine (now at Cornell University's Hudson Valley Laboratory), and Dr. David Kollas, University of Connecticut. Without their help this study could not have been done.

Effects of Planting Density and IPM Level on Apple Fruit Quality

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Many New England apple growers have replanted their orchards with dwarf at densities of 400 to 1000 trees per acre. At the same time, growers have been advancing their efforts to reduce pesticide inputs on their land by employing bio-intensive IPM methods to manage flyspeck disease, plum curculio, pest mites, and apple maggot fly, which together account for almost all pesticide use from about June 10 to harvest. The tree fruit research and extension team at the University of Massachusetts and eight growers have been integrating these horticultural and pest-management practices for the last 2 years.

Just before commercial harvest in 1997, 100 fruit were examined from each of the 48 blocks for symptoms of disease and arthropod damage. As in other experiments of this 3-year study, there were six blocks per orchard and eight orchards. At each orchard there were two high-density blocks, two medium-density blocks, and two low-density blocks. Half of the blocks were managed according to third-level IPM strategies, and half were managed with traditional first-level IPM. The blocks were McIntosh, with an occasional row of Cortland or similar cultivar, and were seven rows by seven trees or as close to this as possible. The feat of selecting and mapping the 48 blocks in eight orchards across the state was considerable and could not have been done without a very supportive and pro-active grower community.

A sub-sample of 20 fruit were selected from each group of 100 for fruit quality evaluations. The 20 were weighed. The percent red color was determined. Firmness was assessed with an Effigi penetrometer, and juice was collected from this process. The percent soluble solids was assessed in the juice with a hand refractometer.

Fruit quality was not affected in 1997 by planting density or IPM level. We hoped that fruit produced

Table 1. Fruit quality (1997) and crop density (1998) of apples from blocks of different planting densities and IPM levels in eight Massachusetts orchards.*

Treatment	Fruit weight (g)	Soluble solids (%)	Red color (%)	Firmness (lbs.)
Planting density				
Low	145 a	10.6 a	60 a	18.0 a
Medium	135 a	10.4 a	66 a	18.9 a
High	135 a	10.4 a	67 a	18.5 a
IPM level				
First	139 a	10.4 a	63 a	18.5 a
Third	139 a	10.5 a	66 a	18.7 a

* Means within column and treatment type not followed by the same letter are significantly different at odds of 19 to 1.

under bio-intensive "third-level IPM" would be as colorful, sweet, large, firm, and as plentiful as fruit produced with more chemically based IPM practices, and this is what we found. We were surprised, however, that there were no differences due to planting density, because other studies have shown high density apple blocks produced larger, more colorful and more plentiful (yield per acre) fruit than blocks with larger less densely planted trees. For 1999, we plan to study these factors more comprehensively. We will increase the number of apples, branches, and trees that are examined.

* * * * *

Evaluation of Flint and Sorvran, Two New Strobilurine Fungicides, Against Apple Diseases

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For the first time in many years, the agricultural chemical industry is releasing new types of fungicides for control of apple diseases. One new class of fungicides, the strobilurines, is particularly interesting. The first registered versions of these on apples are Flint® (trifloxystrobin) and Sovran® (kresoxim-methyl). The original discovery of this class of chemistry was in a forest mushroom, *Strobilurus tenacelius*. In a natural setting, the mushroom produces a chemical called strobilurine to fight off other fungi that may be trying to feed off the forest debris, or off the mushroom itself. Strobilurine A is a natural fungicide. Several companies have synthesized versions of chemicals similar to Strobilurine A, collectively called strobilurines, and are completing evaluation and registration of them.

These fungicides offer some interesting opportunities for apple growers. They are very effective against scab and flyspeck, the two key fungal diseases of apple in New England. In addition, they have a very clean bill of health on the environmental front, with low toxicity to mammals, bees, birds, and earthworms. While toxic to fish and other aquatic organisms, strobilurines are broken down very quickly, and tests show that under normal use patterns, they will not reach water before they break down.

It will also be important to use them wisely, since it will be relatively easy for pathogens to develop resistance to them. Indications are that the resistance that develops will be "all or nothing." That is, if resistance develops, it will come on with little warning, probably leaving significant disease in the wake.

The manufacturers recognize the potential for resistance and attempted to address the problem by limiting the total number of applications that can be made in a year, the amount of material that may be applied in a year, and the number of consecutive sprays of

strobilurines that may be applied. There are differences between the two labels in these respects. The Flint label uses a more cautious approach. For Sovran, the manufacturer "recommends" no more than three applications in a row. The Flint label states "use a maximum of two consecutive applications." The Sovran label says "do not make more than six applications per season". The Flint label carries a five application limit. The Sovran label states that Sovran should not be used as the last fungicide application of the season, while Flint does not have that restriction on the label.

At the very least, the label recommendations and limits should be followed strictly. A conservative approach would be a four application per season limit, with a maximum of two consecutive applications. All strobilurins have the same mode of action, so the limit of four applications per season would apply to the total number of Sovran and Flint sprays. Because strobilurines work well on fruit scab and other diseases, there is no compelling reason to tank-mix them with a broad-spectrum protectant as there is with the sterol inhibitor fungicides. Rather, the manufacturers have chosen to recommend alternating pairs of applications. Pairs of applications made 7 to 10 days apart sounds similar to the "back-to-back" applications recommended for the SI fungicides such as Rubigan and Nova. However, the important point with the strobilurines is to use a different class of fungicide after making two strobilurine applications in order to reduce the chances that resistance will develop. There certainly are a number of unanswered questions about the best way to manage resistance, but that probably argues for taking a relatively cautious approach to using the strobilurines.

Both products exhibit excellent post-infection efficacy, similar to the 4-day activity of the SI fungicides. As you might expect with this sort of post-infection efficacy, the strobilurines are somewhat systemic. The strobilurines show some protectant activity, probably on the order of 3 to 6 days. Therefore, recommended intervals between applications are 7 to

Table 1. Effects of sterol inhibitors, mancozeb, and a cyprodinil/trifloxystrobin treatment on the incidence of scab in mature McIntosh, Belchertown, MA, 1998.

		Scab incidence (%)			
Primary scab season fungicides (per 100 gal.)	Summer fungicides (per 100 gal.)	Terminals	Clusters	Fruit	Fruit (harvest)
Nova 40W+ Dithane 75DF (1.7oz. + 1 lb.)	Captan 50W (1 lb.)	0.4 c	0.0 c	0.6 b	1.8 b
Rubigan 1.6 EC+ Dithane 75DF (2.7 oz. + 1 lb.)	Captan 50W (1 lb.)	1.1 c	0.8 c	1.2 b	1.6 b
Dithane 75DF (1 lb.)	Captan 50W (1 lb.)	14.0 b	11.7 b	2.5 b	1.0 b
Vangard 75WG [pink, bloom]; Flint 50WG [petal fall, 1st cov.] (1.7 oz.; 0.75 oz.)	Flint 50WG+ Captan (2.25 oz. + 1 lb.)	2.0 c	0.4 c	1.2 b	3.2 b
Untreated control		57.0 a	59.9 a	23.7 a	50.0 a

* Means within columns not followed by the same letter are significantly different at odds of 19 to 1.

Table 2. Effects of cyprodonil and trifloxystrobin on incidence of scab in mature McIntosh, Belchertown, MA , 1999.

Primary scab season fungicides (per 100 gal.)	Summer fungicides (per 100 gal.)	Scab incidence (%)			
		Terminals	Clusters	Fruit	Fruit (harvest)
Vangard 75WG (1.7 oz.) 2 applications; then Vangard 75WG (1.7 oz.) plus Dithane 75 DF (1 lb.) through petal fall	Flint 50 WG (0.7 oz.) 10 days after pf; 14 - 21 days	6 b	9 c	1 b	2 b
Vangard 75WG (1.7 oz.) 2 applications; then Vangard 75WG (1.7 oz.) plus Dithane 75 DF (1 lb) through petal fall	Flint 50 WG (0.7 oz.) 21 days after pf; 21 - 28 days	4 b	5 bc	0 b	1 b
Flint 50 WG (0.7 oz.)	Captan 50W (1 lb.)	0 b	0 c	0 b	0 b
Untreated control		31 a	20 a	4 a	4 a

* Means within columns not followed by the same letter are significantly different at odds of 19 to 1.

10 days.

We have tested Flint for the last two years in scab trials, and looked at Sovran in a flyspeck trial this past year. In addition, several other researchers have run tests of one or both of these fungicides in recent years. We show some of the results of our trials here. The scab trials were done at the Horticultural Research Center in Belchertown, with an airblast sprayer. The fungicides were applied on schedules that would normally be used in a growers orchard. However, the manufacturer of Flint wanted to include another new fungicide, Vangard (cyprodonil) in the tests. Vangard represents another new class of fungicide chemistry, but appears to be of limited value to apple growers.

In Table 1 includes 1998 results. It shows that the Flint treatment performed as well as standard Rubigan or Nova plus Dithane treatments against fruit and foliar scab. While the percentages were slightly different, the differences were not significant. By comparison, a low rate of Dithane (1 lb. / 100 gal.) did a relatively poor job of controlling early foliar scab. However, by the end of the summer, following three applications of captan on all treatments, fruit in the Dithane treatment were comparable to those in the other fungicide treatments.

In the 1998 test (Table 2), Vangard performed well when used in combination with the strobilurine. However, the 1999 test suggested that Vangard may not be carrying much of the load in Flint/Vangard combinations. While the differences generally were not significant, there was no scab where Flint was used alone, but 4 to 5 % foliar scab in treatments where Vangard was used in the early season. Scab on fruit at harvest was similar. While this test is not conclusive, data from the Hudson Valley Lab (Rosenberger et al., 1998) showed clearly that Vangard did not control scab as well as Flint when both were used on a 10-day spray interval during the exceptionally wet 1998 season. (Table 3).

Tests for flyspeck control in Belchertown have been less conclusive. This year, the dry weather and the low inoculum in Belchertown made it unlikely that

Table 3. Effects of cyprodonil and trifloxystrobin on incidence of scab in mature Jerseymac, Highland, NY, 1998 (Adapted from Rosenberger et al., 1998).

	Scab Incidence (%)		
Fungicide (per 100 gal.)	Terminals	Clusters	Fruit (harvest)
Vangard 75WG (1.68 oz.) 2 applications; then Flint 50 WG (0.75 oz.) 2 applications; then Flint 50 WG (0.75 oz.) plus Captan 50W (12 oz.).	3.2 b	30.1 b	54.3 b
Flint 50 WG (0.75 oz.)	0.1 c	2.0 c	19.2 c
Flint 50 WG (0.5 oz.)	0.6 c	3.4 c	26.6 bc
Untreated control	67.5 a	97.5 a	100.0 a

* Means within columns not followed by the same letter are significantly different at odds of 19 to 1.

we would get flyspeck. Therefore, we did a single-application test in a block of Liberty trees at the University of Rhode Island East Farm in Kingston. By the time the application was made on July 29, flyspeck was already evident in the test block. Test trees received no fungicides for the season except for the application that was part of this test. Flint and Sovran were compared to Benlate plus captan and to calcium chloride. The results are shown in Table 4 and Figure 1.

Strobilurines performed as well as or better than the best standard treatment, Benlate plus Captan, in a single application. The difference between Flint and Sovran may be due to a rate effect, as it has been suggested that Sovran should be used at twice the Flint rate for equivalent activity. The single application of calcium chloride did not significantly reduce flyspeck at harvest, but did appear to slow the epidemic. It also appears that the effect of the strobilurines lasted for approximately 3 weeks, at which point the rate of flyspeck–symptom appearance in both strobilurine treatments and the Benlate/captan treatment were similar. The early effect meant that at harvest, Flint was still significantly better than Benlate/captan in terms of flyspeck control.

Table 4. Flyspeck severity in apples treated with a single fungicide application on July 29, 1999, Kingston, RI.

Treatment	Flyspeck*
Check	2.73 a
Calcium chloride 80% 10 lbs. / acre	2.46 a
Benlate 50 WP 9 oz. / acre plus captan 50W 3 lbs. / acre	1.64 b
Sovran 3.2 oz. / acre	1.41 bc
Flint 2 oz. / acre	1.14 c

*Rating for each fruit: 0=clean; 1=<10%; 2=10-40%; 3=>40%, Means not followed by the same letter are significantly different at odds of 19 to 1.

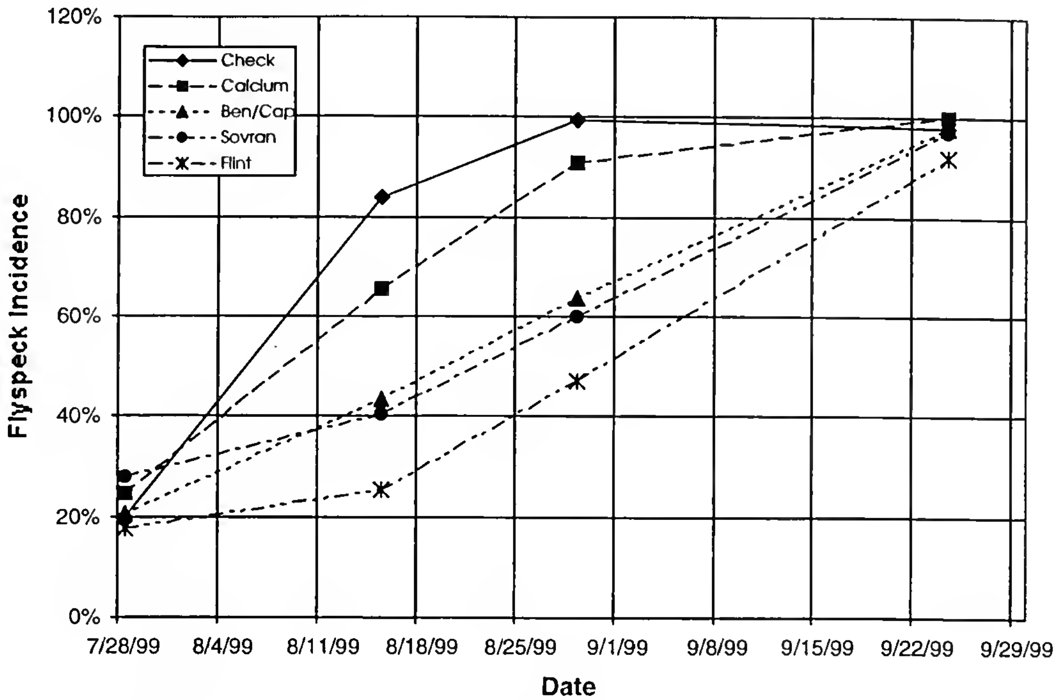

Figure 1. Percentages of fruit showing flyspeck symptoms following sprays with calcium chloride and three different fungicide treatments, Kingston, RI, 1999.

The strobilurines may represent a real opportunity to improve our summer-disease managment. So far, no interactions with mite management have appeared. Residue problems with the strobilurines, as compared to Benlate or captan, might be expected to be minimal. Rather than focusing the strobilurines on scab, it might be useful to reserve at least a couple of applications for flyspeck.

So, should Flint or Sovran be purchased for the 2000 growing season? Both materials have performed very well against scab and flyspeck, so the limiting factor will probably be price. The chemical companies are aware of this, and will probably price the strobilurines to be competitive with the combined cost of an SI plus protectant. Captan or mancozeb alone probably will be cheaper. If price is an issue and growers cut strobilurine rates below the label minimums, then control may not be very good, especially without a protectant to act as a back-up.

Strobilurines are good antisporulants. That is, they prevent active scab from producing large numbers of viable conidia that can cause more infections. They will do a good job stopping or slowing an epidemic. However, more than 96 hrs after the start of an infection, it is unlikely that strobilurines will stop symptom development. With the SI fungicides, applications a few days beyond the 96-hour post-infection recommendation would usually stop symptom development, or limit it to yellow spotting. This will probably not be the case with the strobilurines. In addition, post-infection use will hurry the process to resistance development.

Another factor to consider is what might be called "new product caution." With any new product, unforeseen circumstances may yield unexpected performance problems. While the strobilurines look great, it might be prudent to use them on a limited basis for a year or two. A lot will be learned about the strobilurines as commercial growers begin to use them. In short, use them where the price and timing fits your needs, but do not abuse them by cutting rates, or applying extra applications.

Ottawa 3: A Summary of Twenty Years of Trial

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This article is the second in a series summarizing the data collected in Massachusetts on specific apple rootstocks over a number of years. Ottawa 3 (O.3) is the focus of this installment. The Ottawa series of rootstocks dates back to the 1950's and 1960's. They were selected at the Ottawa Research Station. O.3 resulted from a cross of Robin (a hardy crab apple) and M.9. It is more resistant to collar rot than M.26 and somewhat less resistant than M.9. It is sensitive to fireblight. Propagation has been a problem, but Traas Nurseries in Canada have been relatively successful with tissue culturing of O.3, providing most rootstock liners for nurseries producing finished trees on O.3.

In Massachusetts, the first planting including O.3

Table 1. Characteristics of trees of various cultivars on O.3 in comparison to M.9 and M.26. These data were extracted from several replicated trials, and represent conditions through the end of the 1999 growing season for Golden Delicious, Empire, Rome, and Gala, through 1994 for McIntosh, and through 1993 for Delicious. Fruit size is the average over all fruiting years for each trial.

Tree age (years)	Cultivar	Rootstock	Trunk cross-sectional area (in^2)	Cumulative yield per tree (bu)	Cumulative yield efficiency (lbs/in^2 TCA)	Fruit size (no./42-lb box)
14	Delicious	M.26 EMLA	12.7	27	94	91
		M.9 EMLA	5.2	18	143	86
		O.3	8.8	23	110	88
10	McIntosh	M.26 EMLA	10.2	13	57	115
		O.3	6.9	13	77	115
	Golden Delicious	M.26 EMLA	8.4	9	45	97
		M.9 EMLA	6.5	8	48	101
		O.3	8.0	12	62	95
	Empire	M.26 EMLA	10.9	8	34	108
		M.9 EMLA	4.9	10	80	99
		O.3	7.3	10	63	102
	Rome	M.26 EMLA	9.7	12	55	73
		M.9 EMLA	9.6	13	58	74
		O.3	8.9	12	58	80
6	Gala	M.26 EMLA	7.0	5	31	107
		M.9 EMLA	5.0	4	35	102
		O.3	4.5	5	47	110

was part of an NC-140-coordinated trial established in 1980. This trial included 9 rootstocks with Starkspur Supreme Delicious as the scion cultivar. Since then, additional trials including O.3 were established in 1985, 1990, and 1994 with Summerland Red McIntosh, Smoothee Golden Delicious, Nicobel Jonagold, Empire, and Law Rome as scion cultivars. This article will provide information from all of these plantings, extracting data from each experiment to compare O.3 with M.9 and/or M.26. These data are given in Table 1.

In general, O.3 produced a tree that was intermediate to those on M.9 EMLA and M.26 EMLA rootstocks. Exceptions include scions Rome and Gala, where trees on O.3 were similar in size to those on M.9 EMLA.

Relative to M.26, O.3 yielded somewhat less per tree with Delicious and McIntosh, somewhat more with Golden Delicious and Empire, and similar to M.26 with Rome and Gala. With the exception of Rome, trees on O.3 generally yielded more than those on M.9. In all cases, trees on O.3 were more yield efficient than those on M.26 EMLA. They also were more efficient than trees on M.9 with Gala and Golden Delicious as scions. The practical result of these differences is that O.3 will generally produce a tree that is between M.26 and O.3 in size but will yield more per acre, when appropriately spaced in the field, than trees on M.26.

O.3, M.9, and M.26 all resulted in good fruit size, and there were no consistent differences among the three rootstocks. Overall, average fruit size in these studies averaged about 200 g (96 count), attesting to the fact that these dwarfing rootstocks regularly result in large fruit, even with a lack of irrigation, as was the case in all of the trials.

O.3 was compared with eight other rootstocks (including M.9 EMLA and M.26 EMLA) at 27 sites throughout the U.S. and Canada as part of a cooperative NC-140 trial. After 10 years, trees on O.3 were intermediate in size and yield per tree to those on M.9 EMLA and M.26 EMLA. Trees on O.3 and M.9 EMLA were similarly efficient and significantly more efficient than those on M.26 EMLA.

The data from Massachusetts and from the NC-140 trial suggest that O.3 is a good rootsock, one that is worthy of grower trial. Some studies have grown O.3 unsupported, but in many cases, trees on O.3 lean at the trunk. Therefore, some form of support likely will be beneficial.

* * * * *

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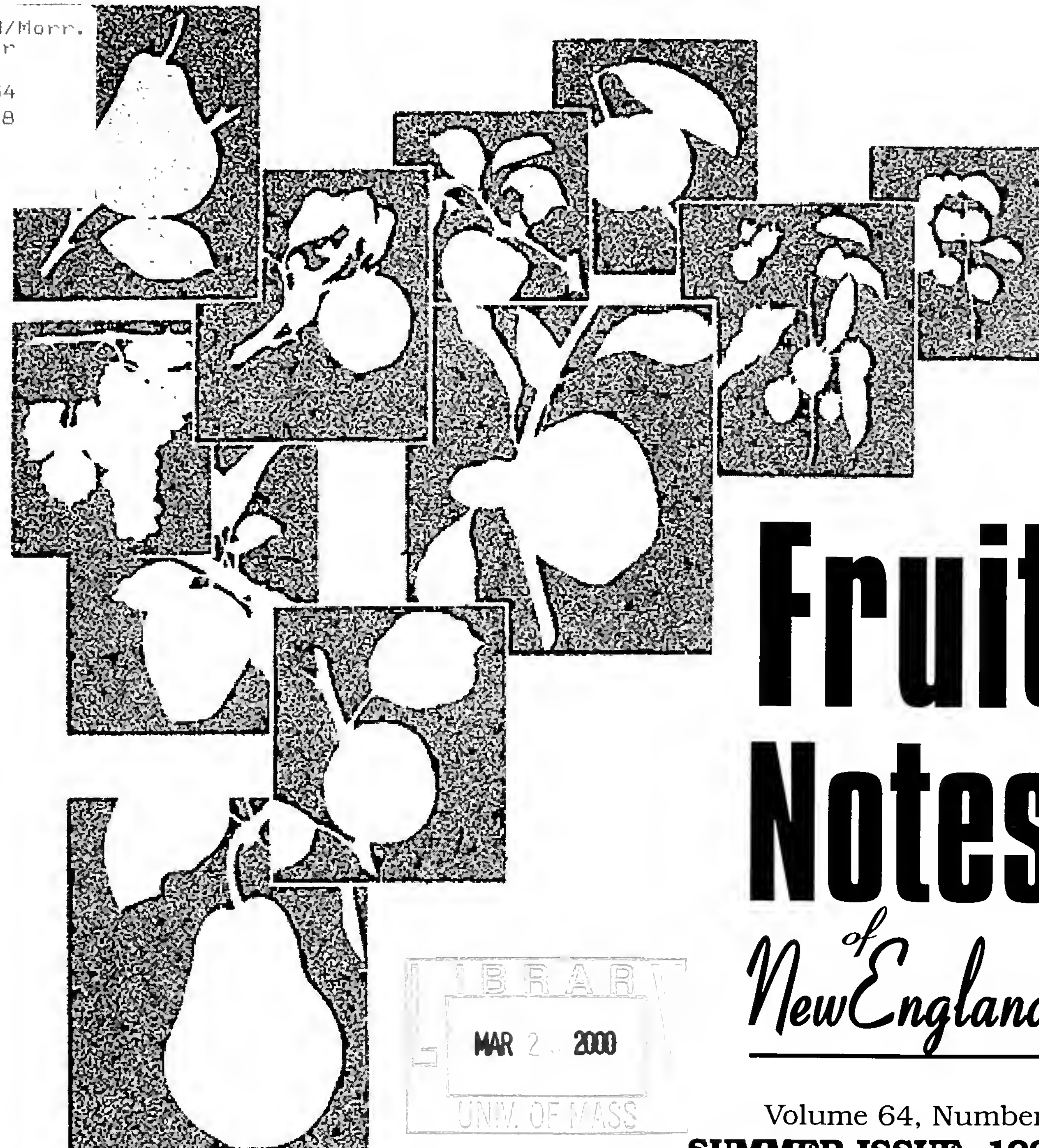

Fruit Notes of New England

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Comparison of Baited and Unbaited Traps for Monitoring Plum Curculios in Apple Orchards

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In the Summer 1998 issue of *Fruit Notes*, we presented two articles describing results of 1998 tests in which we evaluated responses of plum curculio (PC) adults to several different types of unbaited traps in commercial and unsprayed orchards. Here, we report on 1999 tests in which we evaluated not only unbaited but also baited versions of the same types of traps tested in 1998 as well as a new trap type called a circle trap.

Materials & Methods

In eight commercial orchards, we evaluated three types of traps: (a) black pyramid traps (24 inches wide at base x 48 inches tall) placed on the ground next to apple tree trunks, (b) black cylinder traps (3 inches diameter x 12 inches tall) fixed vertically onto horizontal branches within apple tree canopies, and (c) aluminum-screen "circle" traps (developed in Oklahoma for pecan weevils) and wrapped tightly around ascending tree limbs, designed to intercept PC adults walking upward. Traps were placed in six blocks of apple trees in each orchard. Each block consisted of seven perimeter trees. Each tree (save one) contained one unbaited and one baited trap of the above types. The bait consisted of a combination of one polyethylene vial containing limonene and two polyethylene vials containing ethyl isovalerate (components of host fruit odor found to be attractive to PCs in 1998 studies) plus one rubber septum impregnated with grandisoic acid (attractive male-produced pheromone of PC). Vials were attached to the exterior of traps at mid height, and the septum was placed inside the inverted wire-screen funnel (boll weevil trap top) that capped each trap and captured responding PCs. All traps were deployed at bloom and were examined for captured PCs every 3 to 4 days for 6 weeks thereafter. At each trap examination, 15 fruit on each of the seven trees per block were examined for PC oviposition scars. All blocks received two grower-applied sprays of azinphosmethyl to control PC.

In three small unsprayed orchards, we evaluated unbaited and baited pyramid and cylinder traps as well as clear Plexiglas squares (2 feet x 2 feet) fastened vertically 5 feet above ground to wooden poles seated in the ground. One side of each Plexiglas square was coated with Tangletrap to capture alighting PCs. Plexiglas traps were positioned with sticky-side facing woods either 6 feet from the edge of woods or 1 foot outside of perimeter foliage of apple trees. Traps were placed in four blocks of apple trees in each orchard. Each block consisted of six perimeter trees. Each tree contained one unbaited and one baited trap (above type bait) of each trap type. Each block in two of the orchards also received one unbaited and one baited clear Plexiglas trap placed at the edge of woods. All traps were emplaced at bloom. Every 3 to 4 days thereafter for 6 weeks, traps were examined for captured PCs, and fruit were examined for PC scars. No insecticide was applied to any of the blocks.

Results

In commercial orchards, significantly more (about three-times more) total PCs were captured by pyramid traps than by cylinder traps, with circle traps capturing no PCs (Figure 1). There was no significant difference in captures between unbaited and baited traps of any type (Figure 1). Disappointingly, none of the three types of baited or unbaited traps yielded captures whose amount or phenology (pattern of occurrence over time) reflected even in a very minimal way the amount or phenology of egglaying injury to fruit caused by PC. If there were a perfect relationship between trap captures and injury, then the statistical indicator of such a relationship (called r) would have a value of 1.00. Here, the r value describing the relationship between

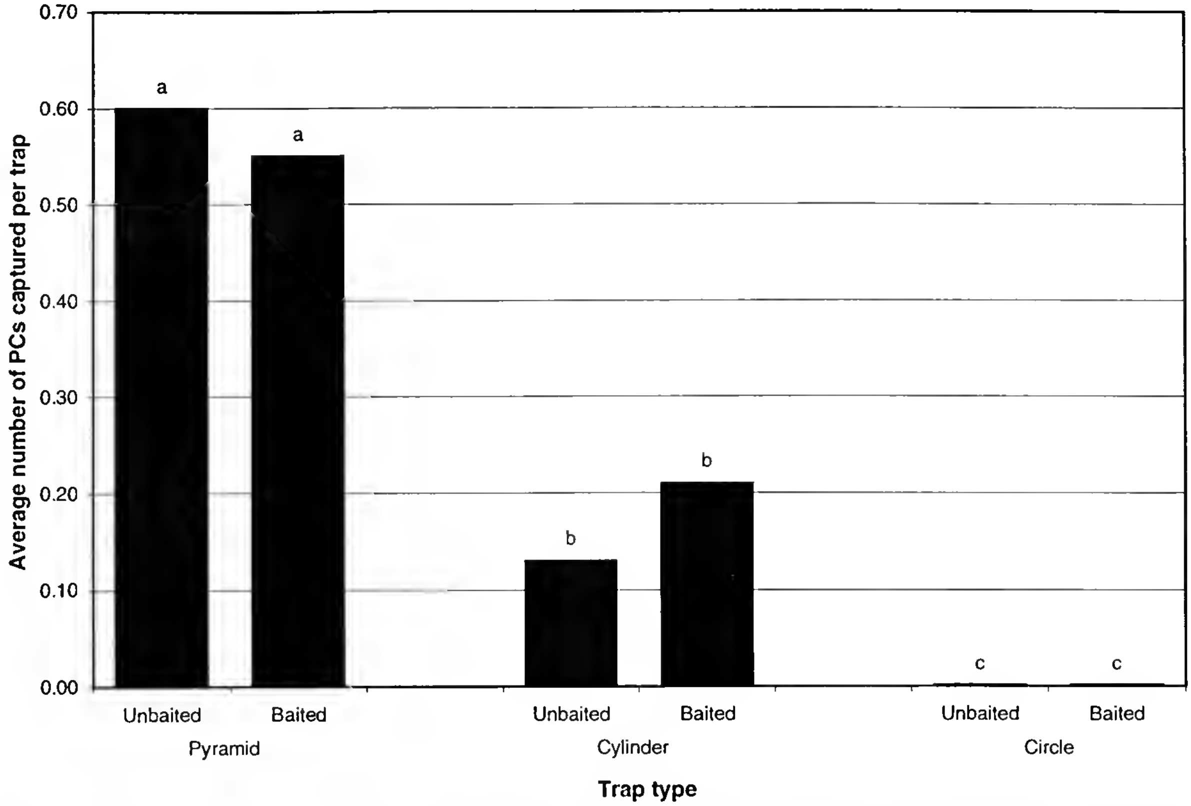

Figure 1. Captures of plum curculios on unbaited and baited pyramid, cylender, or circle traps in commercial orchards. Bars not superscribed by the same letter are significantly different at odds of 19 to 1.

abundance of PCs in traps and amount of injury never exceeded 0.37 for any type of unbaited or baited trap, and the r value describing the relationship between time of capture of PCs in traps and time of injury did not exceed 0.24 for any type of unbaited or baited traps.

In unsprayed orchards, significantly more (about eight times more) PCs were captured by pyramid traps than by cylinder traps, with clear Plexiglas traps positioned next to apple trees capturing slightly, but not significantly, more PCs than cylinder traps (Figure 2). Captures by unbaited versus baited traps did not differ significantly among any of these three trap types (Figure 2). However, baited clear Plexiglas traps placed at the edge of woods captured significantly more PCs (about 14 times more) than similarly positioned unbaited traps (Figure 2). In contrast to above findings in commercial orchards, r values describing the relationship between abundance of PCs in traps and amount of injury ranged between 0.75-0.89 for unbaited and baited pyramid and clear Plexiglas traps placed next to perimeter apple trees. Less encouraging, however, were r values describing relationship between time of capture of PCs in traps and time of injury, which did not exceed 0.22 for any type of unbaited or baited trap.

Conclusions

Perhaps the most encouraging finding from this study was the positive response of PCs to baited sticky clear Plexiglas traps placed next to woods. In the future, a simpler and more attractive version of this type of baited trap could be very useful for monitoring the beginning, peak and (most importantly) the end of immigration of overwintering PCs from woods or hedgerows into orchards.

The reason why odor bait significantly enhanced PC captures by clear Plexiglas traps near woods but not captures by any of the various types of traps placed adjacent to, beneath or within canopies of perimeter apple trees is uncertain but could be related to use of too high a dose of ethyl isovalerate, one of the odors used a component of the bait. The extra high dose used here turned out to be about six times greater than the medium dose found to be attractive in subsequent tests (see following article) and, at close range for PCs

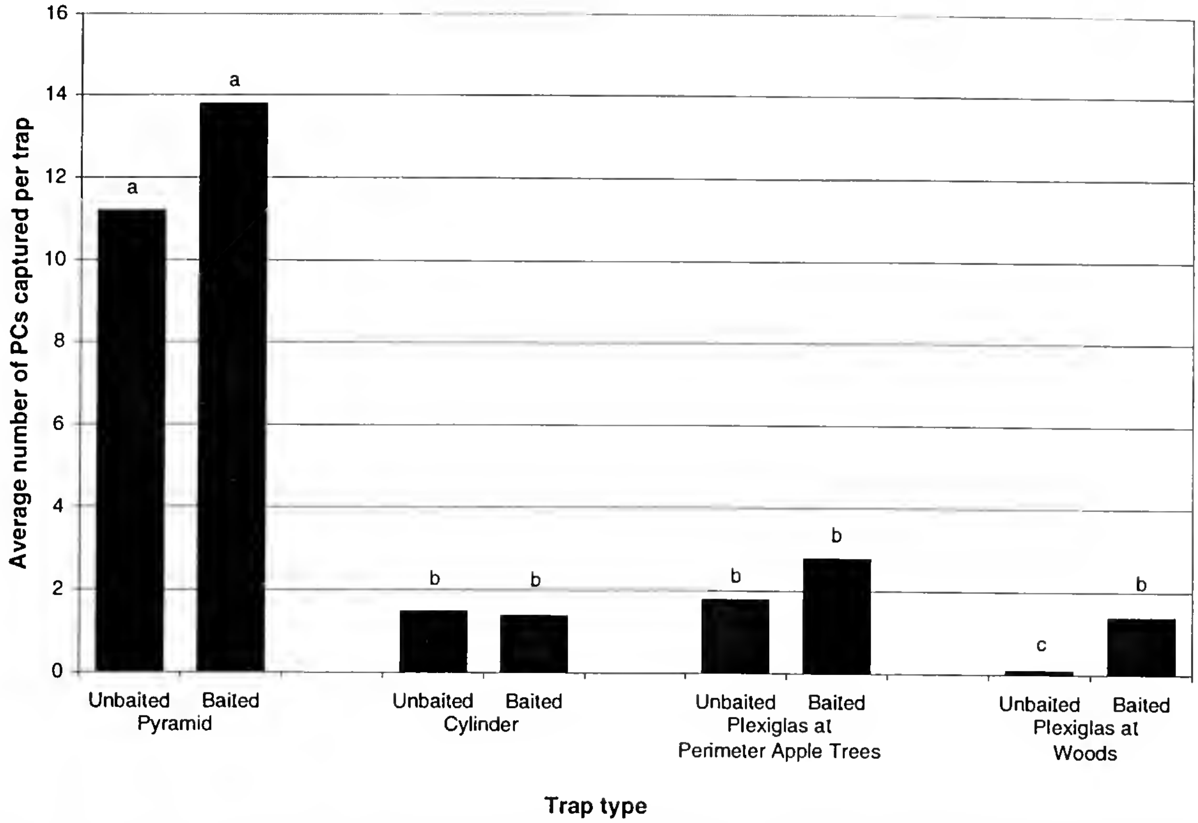

Figure 2. Captures of plum curculios on unbaited and baited pyramid, cylinder, or clear Plexiglas traps in unsprayed orchards. Bars not superscribed by the same letter are significantly different at odds of 19 to 1.

crawling toward pyramid, cylinder, or circle traps, could have negated attractiveness of limonene and/or grandisoic acid.

None of the unbaited or baited traps placed adjacent to, beneath, or within apple tree canopies represented improvement over traps tested in 1998 in terms of ability of trap captures to reflect the time of occurrence of PC injury to fruit. It is of little value to spend more time and effort to deploy PC traps in association with apple trees if one can not realize a principal benefit of doing so: being able to predict time periods when PC injury is most likely to occur based on increases in captured PCs. Further research is needed to achieve this benefit.

Acknowledgements

We are grateful to the eight commercial growers (Bill Broderick, Dana Clark, Dave Chandler, Dave Cheney, Dave Shearer, Joe Sincuk, Tim Smith, and Mo Tougas) who participated in the study and to Jim Hardigg in South Deerfield, who permitted use of his unsprayed orchard at Hardigg Industries. This work was supported by awards from the New England Tree Fruit Growers Research Committee, the USDA Northeast Regional Integrated Pest Management Competitive Grants program, SARE, and Massachusetts State and Michigan State Integrated Pest Management funds.

Fruit Odors Are More Attractive than Conspecific Odors to Adult Plum Curculios

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Many species of weevils are attracted to host plant odors and to weevil-produced aggregation and/or sex pheromones. In many cases, when host plant odors and pheromones are deployed in combination, weevil attraction is greater than to either odor type alone. Plum curculios (PCs) have been shown to be attracted to host fruit odors and to a male-produced aggregation pheromone, grandisoic acid, identified in PCs by Eller and Bartelt of Illinois, but little is known about the level of PC attraction to a combination of host fruit and pheromonal odors.

Successful monitoring systems deploying both host plant and pheromonal odors have been created for several species of weevils. Although a reliable monitoring system for detecting adult PC entry into orchards from overwintering sites does not exist, the deployment of attractive odors such as those from host fruit and/or pheromone in conjunction with a trap that is also visually attractive to adult PCs could prove to be successful.

In the1998 Winter issue of *Fruit Notes*, we presented preliminary results from bioassays conducted in large Plexiglas arenas designed to assess PC attraction not only to fruit odors but also to odors emitted by other PCs. Here we provide more detailed results of PC attraction to fruit odors, odors emitted by other PCs, synthetic grandisoic acid, and fruit odors combined with odors emitted by other PCs or with synthetic grandisoic acid.

Materials & Methods

Large clear Plexiglas arenas with dimensions of 24x24x12 inches and Plexiglas lids were used as still-air arenas for the following experiments. Source materials to be tested as emitting potentially attractive odors were placed in small cotton bags hung in the upper corners (one per corner) of each arena.

Either ten male or ten female PCs starved for 24 hours and chilled 30 minutes prior to testing were released into the center of an arena at the beginning of darkness. Numbers of PCs that crawled to within one-half inch of an odor source held inside a cotton bag were recorded every 10 minutes for 1 hour. Each trial was repeated at least eight times, each time rotating the position of cotton bags containing odor sources.

Treatments tested as potentially emitting attractive odors included five freshly picked wild plums, five male or female PCs, synthetic grandisoic acid impregnated into small rubber septa (at a low and a high dose of 0.03 ug and 3.00 ug, respectively), or five wild plums in combination with five male PCs, five female PCs, grandisoic acid at a low or high dose, or a green fruit worm (GFW) larva. A GFW was used to simulate plums that had been fed upon by a non-PC insect because we wanted to learn if odor released from plums that were being fed upon by PCs and/or odor from PCs that were feeding on plums was attractive to other PCs.

The total number of PC responders to a particular odor treatment was tallied over the six 10-minute intervals for each of the four treatments to provide a total response score for each treatment for every experiment. Results presented here reflect the mean number of PCs attracted to each treatment over all total response scores.

Results

Male Responses to Females. In Arena One (Table 1), males did not respond to the odor of females alone compared to controls, but in Arena Two, males responded to odor of females held with plums in signifi-

Table 1. Mean numbers of male PCs moving to within 1/2 inch or onto cotton bags of each treatment in which female PC odors were included in at least one treatment per arena.

Arena	**Treatments**			
One	*5 Females* 0.9 a	*Control 1* 1.0 a	*Control 2* 0.5 a	*Control 3* 0.4 a
Two	*5 Females* 0.2 b	*5 Plums* 2.4 b	*5 Females + 5 plums* 14.3 a	*Control 1* 0.4 b
Three	*5 Females + 5 plums* 14.2 a	*Control 1* 0.4 c	*5 Males + 5 plums* 6.4 b	*Control 2* 0.1 c
Four	*5 Females + 5 plums* 14.8 a	*Control 1* 0.7 c	*1 GFW + 5 plums* 8.0 b	*Control 2* 0.6 c

* Means within rows not followed by the same letter are significantly different at odds of 19:1.

Table 2. Mean numbers of male PCs moving to within 1/2 inch or onto cotton bags of each treatment in which male PC odors were included in at least one treatment per arena.

Arena	**Treatments**			
One	*5 Males* 0.9 a	*Control 1* 0.4 a	*Control 2* 0.8 a	*Control 3* 0.5 a
Two	*5 Males* 0.2 c	*5 Plums* 5.2 b	*5 Males + 5 plums* 11.3 a	*Control 1* 0.3 c
Three	*5 Males + 5 plums* 11.1 a	*Control 1* 0.2 b	*1 GFW + 5 plums* 8.1 a	*Control 2* 0.5 b

* Means within rows not followed by the same letter are significantly different at odds of 19:1.

cantly greater numbers than to females alone or plums alone. Males also responded to odor of females held with plums in significantly greater numbers than to males held with plums or a GFW held with plums in Arenas Three and Four, respectively.

Male Responses to Males. In Arena One (Table 2), males did not respond to odor of males alone compared to controls, but in Arena Two, males responded to odor of males held with plums in significantly greater numbers than to males alone or plums alone. In Arena Three, males responded in statistically similar numbers to odor of males held with plums and to a GFW held with plums.

Female Responses to Females. In Arena One (Table 3), females responded in significantly greater numbers to females alone compared to controls. Comparisons in Arena Two of odors of females alone, plums alone, and females held with plums yielded statistically similar responses to plums alone and females held with plums, though responses to females held with

Table 3. Mean numbers of female PCs moving to within 1/2 inch or onto cotton bags of each treatment in which female PC odors were included in at least one treatment per arena.

Arena	Treatments			
One	*5 Females* 3.3 a	*Control 1* 0.3 b	*Control 2* 0.0 b	*Control 3* 0.8 b
Two	*5 Females* 0.6 b	*5 Plums* 4.2 ab	*5 Females + 5 plums* 6.7 a	*Control 1* 0.7 b
Three	*5 Females + 5 plums* 7.2 a	*Control 1* 0.3 b	*5 Males + 5 plums* 6.6 a	*Control 2* 0.9 b
Four	*5 Females + 5 plums* 12.6 a	*Control 1* 0.4 b	*1 GFW + 5 plums* 12.3 a	*Control 2* 0.9 b

* Means within rows not followed by the same letter are significantly different at odds of 19:1.

Table 4. Mean numbers of female PCs moving to within 1/2 inch or onto cotton bags of each treatment in which male PC odors were included in at least one treatment per arena.

Arena	Treatments			
One	*5 Males* 3.1 a	*Control 1* 0.3 b	*Control 2* 0.1 b	*Control 3* 0.4 b
Two	*5 Males* 0.9 b	*5 Plums* 7.0 a	*5 Males + 5 plums* 7.6 a	*Control 1* 0.7 b
Three	*5 Males + 5 plums* 14.6 a	*Control 1* 1.1 b	*1 GFW + 5 plums* 6.6 a	*Control 2* 0.0 b

* Means within rows not followed by the same letter are significantly different at odds of 19:1.

plums were significantly greater than to females alone. Females also responded in statistically equal numbers to odor of females held with plums compared to males held with plums and to a GFW held with plums in Arenas Three and Four, respectively.

Female Responses to Males. In Arena One (Table 4), females responded in significantly greater numbers to males alone compared to controls. Comparisons in Arena Two of odors of males alone, plums alone, and males held with plums yielded statistically similar responses of females to plums alone and females held with plums and significantly greater responses to both than to males alone. Females also responded in statistically similar numbers to odor of males held with plums and to a GFW held with plums in Arena Three.

Male Responses to Grandisoic Acid. Males did not respond to odor of grandisoic acid at either a low or high dose in Arenas One and Two, respectively (Table 5). Statistically similar responses were recorded for males to plums alone and to grandisoic acid held

Table 5. Mean numbers of male PCs moving to within 1/2 inch or onto cotton bags of each treatment in which odor of grandisoic acid, either low (l) or high (h) dose, was included in at least one treatment per arena.

Arena	Treatments			
One	*Grandisoic acid (l)* 2.0 a	*Control 1* 1.8 a	*Control 2* 1.9 a	*Control 3* 2.9 a
Two	*Grandisoic acid (h)* 1.3 a	*Control 1* 2.1 a	*Control 2* 2.3 a	*Control 3* 1.4 a
Three	*Grandisoic acid (l)* 1.1 b	*5 Plums* 10.0 a	*Grandisoic acid (l) + 5 plums* 10.5 a	*Control 1* 0.5 b
Four	*Grandisoic acid (h)* 1.0 b	*5 Plums* 5.9 a	*Grandisoic acid (h) + 5 plums* 7.3 a	*Control 1* 1.5 b

* Means within rows not followed by the same letter are significantly different at odds of 19:1.

Table 6. Mean numbers of female PCs moving to within 1/2 inch or onto cotton bags of each treatment in which odor of grandisoic acid, either low (l) or high (h) dose, was included in at least one treatment per arena.

Arena	Treatments			
One	*Grandisoic acid (l)* 3.5 a	*Control 1* 0.9 b	*Control 2* 0.6 b	*Control 3* 0.6 b
Two	*Grandisoic acid (h)* 2.0 a	*Control 1* 1.6 a	*Control 2* 1.8 a	*Control 3* 1.9 a
Three	*Grandisoic acid (l)* 1.8 b	*5 Plums* 11.0 a	*Grandisoic acid (l) + 5 plums* 5.6 ab	*Control 1* 2.3 b
Four	*Grandisoic acid (h)* 1.9 b	*5 Plums* 5.9 a	*Grandisoic acid (h) + 5 plums* 7.9 a	*Control 1* 2.1 b

* Means within rows not followed by the same letter are significantly different at odds of 19:1.

with plums at both the low and high dose in Arenas Three and Four, respectively.

Female Responses to Grandisoic Acid. Females responded in significantly greater numbers to grandisoic acid than to controls at a low dose in Arena One but not at a high dose in Arena Two (Table 6). Statistically equal responses were recorded for females to plums alone and grandisoic acid held with plums at both a low or high dose in Arenas Three and Four, respectively.

Conclusions

We conclude that females produce an odor that is attractive to males, but attraction occurs only when females are feeding on plums. Although females were

attracted to males alone and synthetic grandisoic acid alone in significantly greater numbers than to controls, these responses were quickly lost when host fruit odor was included. Both males and females were equally attracted to odors of males feeding on plums and synthetic grandisoic acid held with plums when compared to plums alone, indicating that attraction to host fruit odor was not enhanced by the presence of male-produced or synthetic pheromonal odor. However, synthetic grandisoic acid impregnated into rubber septa may not have been very attractive due to chemical binding to septa but could be more attractive if formulated differently. In general, our studies revealed that fruit-based odors are the most attractive to PCs and that only minor contributions are made by addition of conspecific odors or grandisoic acid. Therefore, we conclude that attractive fruit-based volatiles should be the main additive to an attractive visual trap to create a successful monitoring system for PCs.

Acknowledgments

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* * * * *

Several Host-odor Compounds are Attractive to Plum Curculio Adults

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As revealed in the preceding two articles, traps developed for monitoring plum curculio (PC) adults in commercial orchards are unlikely to succeed unless baited with powerful attractive odor, the most promising type being attractive host fruit odor. To date, 56 compounds have been identified as components of odor of plum or apple fruit at the most attractive stage to PC (2 weeks after bloom). In the Summer 1998 issue of *Fruit Notes*, we presented results of 1998 tests evaluating 16 of these 56 compounds. Two were found to be attractive to PC: limonene and ethyl isovalerate. Here, we describe results of 1999 tests in which 30 of the 56 host-odor compounds (including the 16 compounds of 1998) were evaluated in field tests for attractiveness to PC.

Materials & Methods

Of the 56 compounds, 46 were identified in the laboratory by Larry Phelan in Ohio and 10 were identified in the laboratory of Sylvia Dorn in Switzerland. We chose to evaluate the 30 compounds that were most readily available from a commercial source (Aldrich Chemical Company) and least expensive to purchase (less than $5.00 per gram).

Each compound was introduced into a 2-dram polyethylene vial and assessed at three different rates of odor release, so as to create a low, moderate, or high dose of odor concentration in the surrounding air. Release rates were varied either by adding mineral oil to the contents of a vial to reduce release rate or drilling small holes in a vial just beneath the cap to increase release rate. Intended release rates for each compound were 3, 12, and 48 milligrams of odor per day, but it was not always possible to achieve intended precision with each compound.

Compounds were assayed in association with yellow-green boll weevil traps placed on the ground beneath perimeters of unsprayed apple tree canopies in Massachusetts and Ohio. PCs frequently drop from host tree canopies to the ground and thus may encounter odor from a nearby baited trap. Each trap was baited either with two vials containing the same compound at the same release rate or two empty vials. Vials were suspended vertically by wire attached to the base of the screen funnel top of the trap. Over a 7-week period from early May to late June, 360 traps were deployed in Ohio and another 360 in Massachusetts for compound evaluation. Traps were examined for captured PCs and rotated in position daily or every other day.

To measure attractiveness of a particular release rate of a particular compound, a Response Index (RI) was created by subtracting the number of PCs responding to an unbaited control trap (C) from the number responding to a baited trap (BT), dividing by the total number of PCs captured by the C and BT traps and multiplying by 100. Thus $RI = [(BT-C)/(BT+C)] \times 100$. The greater the RI, the more attractive the compound at that release rate.

Results

Results (Table 1) show that 13 of the 30 compounds had RI values of 32 or greater (= minimum RI value for statistical significance) at the most attractive release rate. In descending order of attractiveness, these were E-2- hexenal (RI=90), hexyl acetate (67), decanal (64), limonene (64), geranyl propionate (59), 1-

Table 1. Response index (RI) of plum curculio adults to 30 host fruit odor compounds evaluated at three different release rates. For each compound, only that release rate which yielded the highest RI value of all (either from Massachusetts or Ohio) is given.

Compound	Release rate	RI*
Benzaldehyde	Low	46
Benzonitrile	Medium	-7
Benzothiazole	High	27
Benzyl Alcohol	Low	44
Decanal	Low	64
Ethyl Acetate	High	13
Ethyl Butyrate	Medium	4
Ethyl Isovalerate	Medium	40
Geranyl propionate	Medium	59
1-Hexanol	Medium	13
2-Hexanol	High	32
3-Hexanol	Medium	4
2-Hexanone	Medium	4
3-Hexanone	High	13
E-2-Hexenal	Medium	90
Hexyl Acetate	High	67
3-Hydroxy-2-butanone	High	27
Isopropyl acetate	Low	20
Limonene	Medium	64
Linalool	High	13
3-Methyl-1-butanone	Medium	-7
2-Methyl-3-buten-2-ol	Medium	13
1-Pentanol	Medium	59
2-Pentanol	High	35
3-Pentanol	Medium	4
1-Penten-3-ol	High	4
Phenylacetaldehyde	High	32
2-Phenylethanol	Low	20
2-Propanol	Medium	32
E-2-Nonenal	Medium	0

* RI values of 32 or greater are significantly different from zero at odds of 17 to 1.

pentanol (59), benzaldehyde (46), benzyl alcohol (44), ethyl isovalerate (40), 2-pentanol (35), 2-hexanol (32), phenylacetaldehyde (32), and 2-propanol (32).

Conclusions

These results strongly confirm previously-reported attractiveness of limonene and moderately confirm previously-reported attractiveness of ethyl isovalerate. In addition, five other compounds not among the 16 compounds tested in 1998 were found to be notably attractive here (RI value of 40 or greater): benzyl alcohol, decanal, geranyl propionate, hexyl acetate, and 1-pentanol. Also, two compounds that were among the 16 tested in 1998, but not found to be attractive then, were attractive here (perhaps because of a more favorable release rate here): benzaaldehyde and E-2-hexenal. These findings offer promise that one or more of these attractive compounds alone (or together in a blend) at an appropriate release rate can be applied to visual traps to substantially enhance capture of PCs.

Acknowledgements

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Evaluation of Kaolin Clay (Surround™) for Control of Plum Curculio

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Developing an effective trap for monitoring plum curculio (PC) in orchards would provide a means for determining the need and time to apply an insecticide treatment for controlling this pest. The question then arises of what insecticide to use. For the past 30 or more years, azinphosmethyl and phosmet have been the recommended materials against PC. Conceivably, new regulations under the Food Quality Protection Act may seriously compromise future use of these and other insecticides in orchards.

Therefore, in 1999 we decided to evaluate a new material, called Surround™, as a candidate for controlling PC. It consists entirely of particles of white kaolin clay, the same clay in fact that is used in porcelain pottery. Research to date by Michael Glenn and Gary Puterka of USDA's Appalachian Fruit research Laboratory in Kearneysville, West Virginia suggests that insects contacting foliage or fruit sprayed with an aqueous solution of Surround are not killed but instead are repelled. Apparently, the clay particles are very annoying to insects walking on treated surfaces and cause them to seek food and egglaying sites elsewhere.

Our 1999 tests of Surround against PC consisted of a small-scale trial conducted in a commercial orchard and preliminary trials conducted in the laboratory.

Materials & Methods

The orchard trial was carried out at the Prokopy Orchard in Conway using six rows of Liberty trees, each with five trees per row. Every other row was sprayed twice with Surround: once on May 31 (one week after petal fall) and again on June 8. Surround was applied at the recommended rate: 50 pounds per 100 gallons water, along with a manufacturer-provided adjuvant at 1 pound per 100 gallons water. Remaining rows were sprayed once (May 31) with phosmet at the recommended rate: 1 pound of 70WP per 100 gallons water. A single perimeter tree in another row did not receive any insecticide against PC and served as an untreated control. No PC injury was observed in samples of fruit taken prior to insecticide application. On June 17 (just before June drop), ten fruit were sampled for curculio injury on each treated or untreated tree. Only 1/6 inch of rain fell between May 31 and June 17.

The laboratory trials involved caging PC adults singly with either (a) one untreated apple or one apple sprayed with Surround and adjuvant at above rate (termed a no-choice test), or (b) one untreated apple together with one Surround-treated apple (termed a choice test). These trials were conducted in August using adults that emerged from pupae about 2 weeks before testing and were starved for 1 day before testing. Apples were examined 24, 48, and 120 hours after initial exposure for feeding punctures made by adults (young adults, as used here, are unable to lay eggs).

Results

Results of the orchard trial showed that averages

Table 1. Percent apples injured by plum curculio adults in commercial orchard trees receiving two applications of Surround, one application of phosmet, or no treatment.

Treatment	Number of trees	Injured apples per tree (%)
Surround	15	6.0
Phosmet	15	3.3
Untreated	1	30.0

Table 2. Number of punctures in apples made by newly-emerged plum curculio adults confined singly in laboratory cages with either one Surround-treated apple together with one untreated apple (choice test) or one Surround-treated apple alone vs. one untreated apple alone (no-choice test).

Test	Apples	Number of replications	Mean no. punctures per fruit after 24 hours	48 hours	120 hours
Choice	Treated	36	0.0	0.0	0.0
	Untreated	36	1.7	2.8	4.7
No choice	Treated	36	0.4	0.8	1.8
	Untreated	36	1.7	3.3	5.8

of 3.3, 6.0, and 30.0% of sampled fruit were injured by PCs on phosmet-treated, Surround-treated, and untreated trees, respectively (Table 1). Results of laboratory trials showed that in choice tests, where adults could choose to feed on either an untreated or a Surround-treated apple, all feeding occurred on untreated apples (Table 2). However, in no-choice tests, where adults remained hungry if they did not feed on the lone type of apple provided, punctures on Surround-treated fruit reached about one-fourth the number on untreated fruit 24 and 48 hours after trials began and reached about one-third the number on untreated fruit after 120 hours.

Conclusions

Our combined findings suggest that Surround has definite potential as a material for preventing PC injury. In the orchard trial, two sprays of Surround were about half as effective as one spray of phosmet in preventing curculio injury. In laboratory trials, Surround was completely effective in deterring feeding by PCs on treated apples under conditions where untreated apples were nearby but was less effective in the absence of accessible untreated apples. These results indicate, therefore, that unless coverage of foliage and fruit by Surround is complete over space and continuous over time, Surround may not be able afford total protection against injury by PCs. A possible scenario for future control of PC could involve treatment of the great majority of trees in an orchard block with Surround coupled with placement of odor-baited visual traps at untreated trees to capture deterred but still-foraging adults.

As a final note, a new wettable-powder formulation of Surround has been developed that is reported to have greater residual effectiveness after rainfall than the formulation used in our 1999 tests. This new formulation is now officially registered for use on apples. After an application of Surround, the foliage and fruit are covered with a thin layer of white clay particles, giving the tree a white appearance. Rather than being a drawback, this is said to improve fruit color and fruit size.

Acknowledgements

We thank both Gary Puterka of the USDA Fruit Research laboratory in Kearnesyville, WV and Engelhard Corporation for providing the Surround and adjuvant in our tests.

* * * * *

Food Quality Protection Act: An Update, February 2000

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Although the Food Quality Protection Act of 1996 requires that the EPA review all active ingredients currently registered, the spotlight continues to focus on the organophosphate (OP) class of compounds. These materials, the majority of which are insecticides, are labeled for a wide variety of uses including agricultural, veterinary, residential, and structural. EPA must first assess the aggregate risk to human health posed by these compounds on an individual basis by considering all potential routes of exposure. Cumulative assessment of the OP's as a group will be conducted at a later date.

To date, only two (azinphos methyl and methyl parathion) of the five active ingredients most commonly used in commercial tree fruit production have completed the EPA's six-step initial review process culminating in risk management recommendations. The balance (chlorpyriphos, dimethoate, and phosmet) is currently under active review. Discussions of two materials with only limited usage in tree fruits (diazinon and malathion) have only recently been initiated. The following is a summary EPA's findings and actions as of February 21, 2000.

Azinphos methyl – The initial review of azinphos methyl (Guthion, Sniper) was completed on August 2, 1999. As registered at that time, EPA concluded that azinphos methyl posed an unacceptable dietary risk to children ages 1 to 6 years, risks of concern to agricultural workers, and unacceptable ecological risks. To mitigate occupational and environmental concerns, the registrants volunteered to amend their labels by agreeing to delete the use of azinphos methyl on cotton in Louisiana and east of the Mississippi River on sugarcane, ornamentals (except for nursery stock), Christmas trees, shade trees, and forest trees.

The majority of label amendments effecting tree-fruit production were made prior to the 1999 growing season as the registrants were aware of EPA's concerns prior to the final decision and acted accordingly. Additional changes for the upcoming season include a reduction in total amount of product allowed per acre per season from 12 to 9 pounds, a variable preharvest interval dependent on late-season application rates, and a prohibition on application by fixed-wing aircraft.

Methyl parathion – The revised risk assessment for methyl parathion (Penncap-M) also was made public in early August 1999. Although not widely used in the Northeast, methyl parathion has historically been applied to approximately 20% of the apple acreage and nearly 50% of the peach acreage in the U.S. EPA indicated their primary concern was acute dietary risk to children, a portion of the population specifically addressed by the FQPA.

In order to reduce the risk to this sensitive subpopulation, EPA accepted the registrant's voluntary cancellation of all children's food uses including fruit (apples, peaches, pears, grapes, nectarines, cherries, and plums), carrots, succulent peas, succulent beans, and tomatoes effective December 31, 1999. Additional food uses have been cancelled as well as non-food uses such as ornamentals, nursery stock, grasses grown for seed, and mosquito control.

Phosmet – Phosmet (Imidan) has reached a critical point in the review process. EPA's revised risk assessment was released and a technical briefing was held in Pasco, WA on February 10. This event officially began the 60-day public-comment period for submitting risk-mitigation proposals. The revised risk assessment indicated that acute dietary risk was **not** an issue, as phosmet accounted for an average of only 5% of the "risk cup" for all sub-groups. EPA also indicated that exposure to handlers (mixer/loader/applicators) could be managed satisfactorily with increased personal protective equipment and engineering controls such as closed loading systems and enclosed cabs.

However, EPA voiced concern for post application workers who may contact residues. Current information indicates that, depending on the rate used, acceptable margins of exposure may not be met until 37 to 52 days after application. Re-entry intervals of

this magnitude would virtually eliminate phosmet as a pest-management option for many crops. The registrant and other meeting participants raised objections to some of the assumptions EPA used to compile the worker exposure assessment and presented information as to how the assessment could be refined further during the risk-mitigation phase.

Occupational exposure is regulated under FIFRA (Federal Insecticide, Fungicide and Rodenticide Act), **not FQPA**. As such, EPA is obligated to consider the benefits of a particular material when assessing its risk. Attendees reiterated to the EPA panel the importance of phosmet in existing IPM programs, its relatively low acute toxicity, its low impact on many beneficial species, the lack of viable alternative pest-management options, and the uncertain effects of potential replacement products on the crop ecosystems for consideration in determining the re-entry interval. EPA should release their risk-management recommendations by late May to early June.

Dimethoate – Dimethoate (Cygon) is currently in phase five of the review process since the release of the revised risk assessment and technical briefing in mid December. As with methyl parathion, this material has not been an important tool for producers in the Northeast but according to USDA surveys, dimethoate is applied to 35% of the total U.S. apple acreage and is labeled for approximately 40 other food crops.

Despite its widespread usage, EPA is not concerned with aggregate risk from diet or drinking water. Worker exposure and ecological issues seem to be their main concern. The registrants, U.S. Apple Association, and EPA currently are discussing methods to reduce this risk in tree fruits by utilizing increased the requirement for personal protective equipment, decreasing the maximum seasonal rates per acre, and lengthening re-entry intervals for high contact activities such as hand thinning, summer pruning, and harvesting.

Chlorpyrifos – Chlorpyrifos (Lorsban) is somewhat in limbo in stage four of the review process. The public-comment period following the preliminary risk assessment ended December 27, and EPA currently is reviewing any new information that may have been put forth in preparation for releasing their revised risk assessment. No date has yet been set for the technical briefing, but it should occur sometime in late March. After that event, there will be another 60-day public-comment period, and then EPA will have up to 60 additional days to compile the final risk-mitigation proposal.

Diazinon and malathion – Both of these materials have just begun the review process. EPA has shared their first-tier risk assessments with the registrants for error comments only. Preliminary risk assessments have yet to be released for public review.

It is clear that EPA is making deliberate progress in implementing the legislation passed in August 1996. Initial review of the OP's should be completed by the third quarter of this year. The focus will then shift to the next two priority groups of pesticides: carbamates (Benlate, Topsin, Sevin, Lannate, Vydate) and potential carcinogens (Captan, mancozeb, Polyram), many of which are prominently used in commercial fruit production.

To date, with a few notable exceptions, dietary issues have played a secondary role to worker-exposure concerns in assessing the OP's. This may change in the future as EPA looks at cumulative risks associated with materials that have similar modes of action. In September 1999, the Scientific Advisory Panel agreed with EPA's intention to group certain carbamate pesticides with the OP's when assessing cumulative risk. Placing more materials in the same "risk cup" could reduce substantially the number of labeled uses that could be retained and still satisfy the requirements of the FQPA. Cumulative risk assessments have not been a part of the registration process in the past, and EPA has been working on the protocols needed to carry out this aspect of the legislation concurrent with their initial reviews of individual compounds.

It is uncertain how the FQPA will ultimately affect commercial agriculture, but it undoubtedly will change our pesticide-usage patterns. With the increased restriction on uses of older compounds, we must strive to keep up with the introduction of new and innovative pest-management options. Change is the only constant.

Fruit Notes

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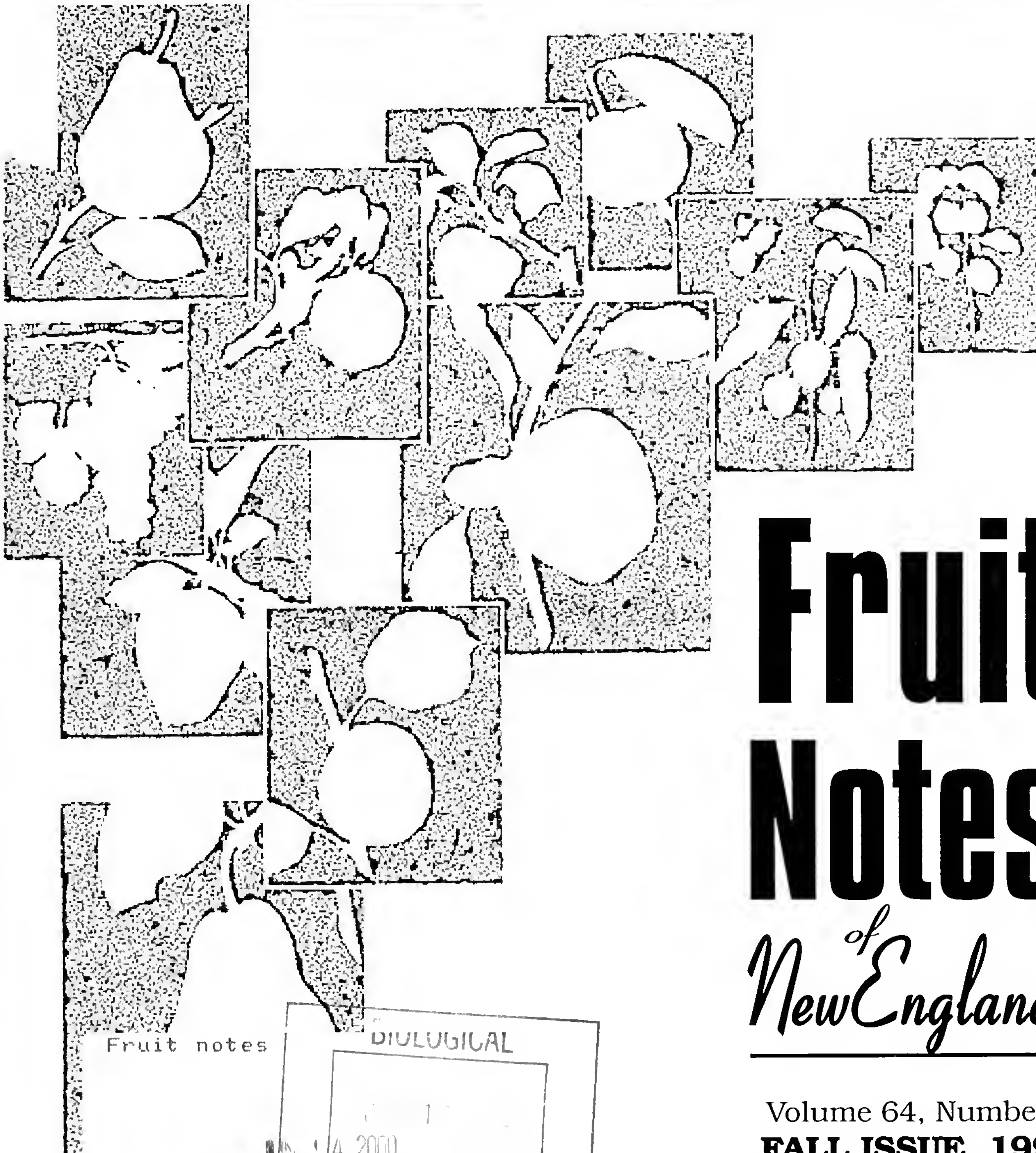

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Effects of Planting Density and IPM Level on Apple Fruit Quality and Crop Density, 1999 Results

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Many New England apple growers have been replanting their orchards with dwarf trees at densities of 400 to 1000 trees per acre. At the same time, our research team and a growing number of orchardists are reducing pesticide inputs by employing bio-intensive IPM methods to manage the diseases flyspeck and sooty blotch, pest mites, and the insect pests apple maggot and plum curculio. These pests account for almost all pesticide applications from about June 10 to harvest. The integration of these horticultural and pest-management practices into a third-level IPM program has been our focus for the last 3 years. This article reports on the effects of planting density and IPM level on apple fruit quality and crop density for the 1999 growing season.

The tree-fruit research team performed crop density and yield counts and collected apples for analysis in 48 apple orchard blocks as close to harvest as possible. As with other experiments of this 3-year study, there were six blocks per orchard and eight orchards. Blocks were comprised of McIntosh, with an occasional row of Cortland, or similar cultivar, and were seven rows by seven trees in size. At each orchard, there were two low-density blocks, two medium-density blocks, and two high-density blocks. One block at each density was managed

Table 1. Fruit quality characteristics of apples from blocks of different planting densities and IPM levels in 8 Massachusetts orchards, 1999.

Treatment type	Fruit weight (g)	Soluble solids (%)	Red color (%)	Flesh firmness (lbs)
Planting density				
High	145 a	13 a	68 a	19 a
Medium	130 a b	13 a	64 a	19 a
Low	126 b	12 a	58 a	19 a
IPM level				
First	132 a	13 a	65 a	19 a
Third	134 a	13 a	62 b	19 a

Means within each column and treatment type not followed by the same letter are significantly different at odds of 9 to 1.

Table 2. Number of fruit from apples trees at different planting densities and managed with different IPM levels, 1999.

Treatment type	Number of harvested apples per tree	Number of dropped apples per tree
Planting density		
High	155 c	13 c
Medium	291 b	18 b
Low	761 a	55 a
IPM level		
First	391 a	23 a
Third	423 a	36 a

Means within each column and treatment type not followed by the same letter are significantly different at odds of 19 to 1.

according to third-level IPM strategies, and the other was managed with traditional first-level IPM strategies.

What were the bio-intensive methods employed in our third-level blocks? Summer diseases were managed with a fungicide-reduction plan tailor-made for each block according to risk assessment. A flyspeck prediction model was developed with these results, and with continued environmental monitoring we hope to refine our understanding of orchard disease ecology. Traps that attract plum curculio visually and olfactorally were developed to monitor and manage this most challenging pest. Beneficial predatory mites were seeded into third level blocks to manage pest mites. Traps and products to manage the apple maggot with little or no insecticide are being refined each year.

Samples of 50 apples (150% more than in the 1997 evaluation) were selected for fruit quality evaluations from a larger sample of 200 fruit that were evaluated for pest incidence in each block at harvest. The 50 fruit were weighed, evaluated for percentage of red (scale 0-100%), assessed for firmness, and tested for soluble solids (sucrose). We evaluated a total of 2,400 apples from the 48 blocks.

There were significant differences among the three planting densities for weight. Apples in dwarf trees planted at high densities produced larger apples on average (145 g) (Table 1) than fruit in the low-density plantings (126 g), but medium density plantings (130 g) produced fruit which were not statistically different from those from either high or low planting densities. Planting density did not affect soluble solids, red color, or flesh firmness. Relative to IPM level, fruit produced under bio-intensive 'third-level-IPM' were less red (62%) than fruit in first-level blocks (65%), but no differences existed for fruit weight, soluble solids, or flesh firmness.

Just before commercial harvest, yield and crop density was estimated. At the corners and centers of each block, the total number of apples on and under the trees were counted. Also, 20 trees from each block (100% more than in 1997) were selected randomly and the circumference of a single representative limb, at the narrowest point before branching, was measured. All fruit from the point of measure to the end of the terminals (including subsequent branching) were counted.

Table 3. Estimated yield of apples trees at different planting densities and managed with different IPM levels, 1999.

Treatment type	Number apples per acre (1000's)	Bushels per acre
Planting density		
High	94 a	730 a
Medium	77 a	530 a
Low	77 a	510 a
IPM level		
First	79 a	560 b
Third	87 a	610 a

Means within each column and treatment type not followed by the same letter are significantly different at odds of 19 to 1.

In 1999, the number of fruit per tree was indirectly related to density (i.e., the high-density, or smaller trees, had fewer fruit than did low-density, or larger, trees), but estimated yield (either as number of fruit per acre or bushels per acre) was unaffected by density (Tables 2 and 3). Third-level IPM, on the other hand, resulted in similar number of apples per tree as first-level IPM but resulted in significantly greater estimated yields per acre (Tables 2 and 3). Crop density was not affected by IPM techniques but was slightly greater for low-density plantings than for high-density plantings (data not shown).

These data suggest that planting density affected some aspects of fruit quality and yield but not others. Clearly, a high degree of variability still exists among blocks in this trial. To further define the relationships, additional blocks will be required. All results to date, however, suggest that bio-intensive IPM can result in a similar product and yield with lower chemical inputs. As we finish analyzing related parts of this 3-year study, such as the effects of planting density on light penetration, temperature, and relative humidity in the apple tree canopy, we hope to improve our understanding of the complex interactions among horticulture, tree and orchard architecture, and IPM in apples.

Acknowledgements

We are grateful to the eight growers who participated in this study: Bill Broderick, Dave Chandler, Dave Cheney, Dave Shearer, Joe Sincuk, Tim Smith, and Mo Tougas. This work was also supported by State/Federal IPM Funds and SARE Grant #97 LNE 97-90 (USDA 96-COOP-1-2700).

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Storage and Shelf life of Several Promising Late-summer-maturing Apple Varieties

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Returns that growers in New England receive for their fruit is diminishing, since the cost of production is increasing faster than the price received for fruit. Growers are attempting to improve profitability on their farms in a variety of ways. One option that we would like to explore here is to increase and expand the sale of apples in the weeks prior to the start of the McIntosh season. New, high-quality varieties are available that ripen in late August and early September. These varieties appear to offer a real possibility for expanded sales. The purpose of this article is to communicate recent findings about the quality, storage potential, and shelf life of three of the most promising early-maturing new apple varieties, Ginger Gold, Sansa, and Sunrise. Paulared ripens at a similar time, thus it is included in this discussion as an industry standard.

Materials & Methods

All fruit used in this investigation were harvested from 5- and 6-year-old trees growing in the variety evaluation block at the University of Massachusetts Horticultural Research Center in Belchertown. This experiment was conducted in 1996 and 1997. In 1996, Ginger Gold, Sansa, and Paulared were evaluated, and in 1997, Sunrise was included with Ginger Gold, Sansa, and Paulared.

In each year, 100 fruit of each variety were harvested on August 29 for evaluation. Varieties were separated randomly into five bags of 20 fruit each. Four of the bags of each variety were placed in air

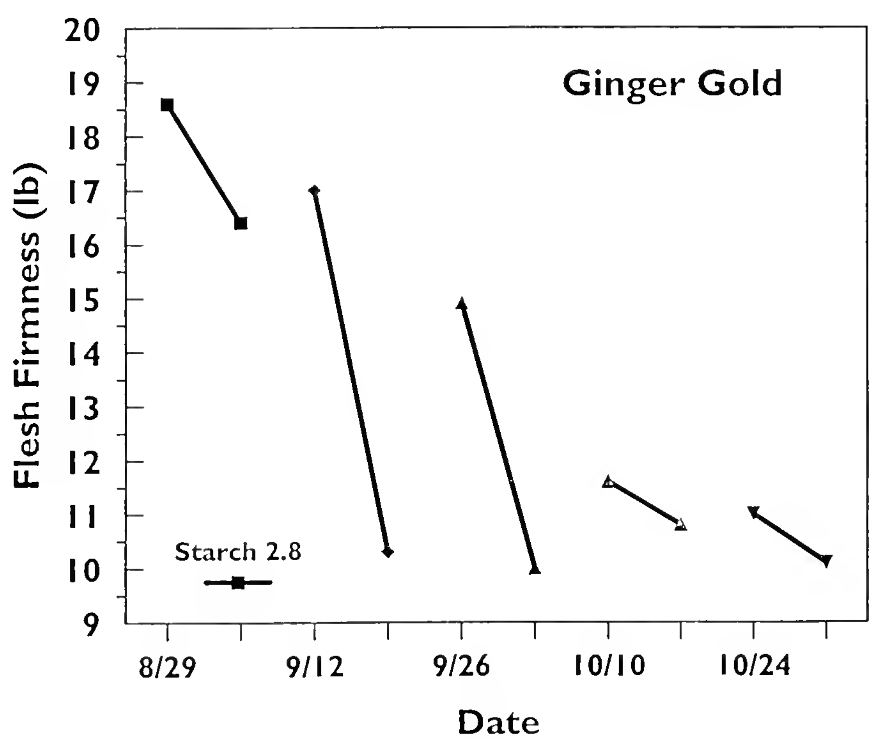

Figure 1. Flesh firmness of Ginger Gold fruit immediately following 0 (at harvest), 2, 4, 6, and 8 weeks of storage at 32°F (represented by the first point of each line) and after 1 week at room temperature (represented by the second point of each line).

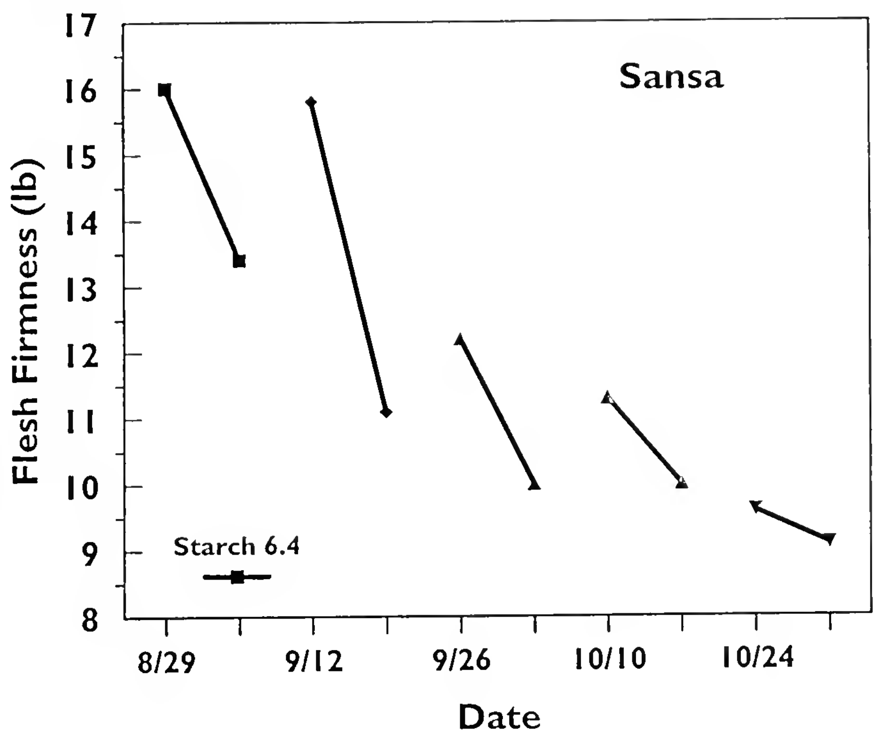

Figure 2. Flesh firmness of Sansa fruit immediately following 0 (at harvest), 2, 4, 6, and 8 weeks of storage at 32°F (represented by the first point of each line) and after 1 week at room temperature (represented by the second point of each line).

storage at 32°F for future evaluation. Flesh firmness of ten fruit was evaluated using a McCormick Fruit Company penetrometer. They were then cut in half and dipped in iodine solution and rated for starch staining on a scale of 1 to 8 using the Cornell Generic Starch Chart. The remaining ten fruit were kept at room temperature for 7 days, after which flesh firmness was measured. On September 12, September 27, October 11, and October 25 the remaining bags of fruit were removed from storage. Flesh firmness of ten fruit was assessed immediately, and firmness of ten fruit was measured after 7 days at room temperature.

Results

Results in 1996 and 1997 were very similar for all varieties, so only the 1997 data are presented.

Ginger Gold (Figure 1). The average starch rating of Ginger Gold fruit was 2.8 at harvest, and fruit had a flesh firmness of 18.6 pounds. When left a room temperature for 1 week, firmness dropped to 16.4 pounds. When Ginger Gold fruit were removed from storage 2 and 4 weeks after harvest flesh firmness was still very good, at 17 and 14.9 pounds, respectively. However, when these fruit were allowed to remain at room temperature for 1 week, flesh firmness drop abruptly to 11 pounds. Fruit stored for more than 4 weeks were soft, tasted somewhat grainy, and were considered to have marginal quality at best.

Sansa (Figure 2). When harvested on August 29, Sansa had an average starch rating of 6.4 and flesh firmness of 16 pounds. After 2 weeks in storage, firmness was similar. Fruit that were kept at room temperature after harvest or after 2 weeks of storage softened, but the taste of these fruit was still good because of the pear-like texture of the flesh. After a month in storage, flesh firmness dropped below 12 pounds, and after 6 weeks in storage, flesh firmness and fruit quality were marginal.

Sunrise (Figure 3). The average starch rating of Sunrise fruit at harvest was 6.1, and firmness was near 14 pounds. Firmness during the first 2 weeks of storage dropped little. Fruit that were allowed to remain at room temperature, either at harvest or after any length of storage, became extremely soft and commercially unacceptable for sale, with flesh firmness ranging between 6 and 8 pounds.

Paulared (Figure 4). The average firmness of Paulared at harvest was 15.5 pounds with a starch rating of 3.6. After storage for 2 or 4 weeks, fruit were still in good condition with firmness of 14.9 and 12.7 pounds, respectively. Fruit that were stored for 6 or 8 weeks had firmness between 10 and 11 pound and

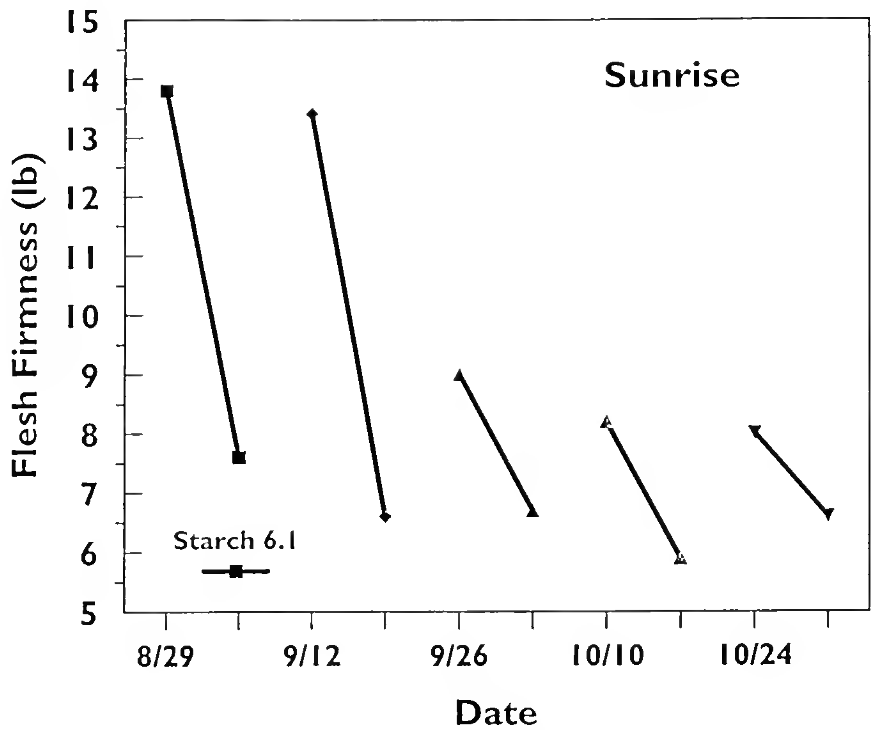

Figure 3. Flesh firmness of Sunrise fruit immediately following 0 (at harvest), 2, 4, 6, and 8 weeks of storage at 32°F (represented by the first point of each line) and after 1 week at room temperature (represented by the second point of each line).

were considered marginal. Paulared fruit that were kept at room temperature for 1 week after harvest had a firmness of 12.4 pounds and were considered quite good. However, any Paulared fruit that was placed in storage and then allowed to stay at room temperature for 1 week had flesh firmness of less than 9 pounds, and were judged to be marginal.

Discussion

The apples evaluated in this study should be considered summer or late-summer apples, and as such we should not expect them to have a long storage life. In general, that conclusion was confirmed in this study.

Experience has shown that the rate of ripening of Ginger Gold is slowed on the tree. Because it is mild tasting and has relatively low tannin content, it is picked commercially at a low starch rating, frequently below 2.0. Consequently the harvest period for Ginger Gold may exceed 3 weeks. However, once Ginger Gold is harvested and placed in cold storage, it has a storage potential of only 4 or 5 weeks. Ginger Gold is unlike some varieties in that when it softens to 12 pounds or lower, the flesh becomes grainy and undesirable. Ginger Gold should be sold before high-quality and better-storing Golden Delicious types are harvested.

Sansa is very similar in appearance and taste to Gala. To the untrained, it could be easily mistaken for Gala. Sansa at harvest and for a month after maintained good to excellent firmness and exceptional flavor. As Sansa softens it develops pear-like characteristics, making it acceptable at lower firmness than other varieties. However, given the similarity between Sansa and Gala, and the generally longer storage potential of Gala, we suggest that only sufficient Sansa should be planted to satisfy grower market demands up to and into Gala season.

At its prime, Sunrise is one of the crispest and best apples available. However, like many summer apples it maintains condition on the trees for only a short time. This study suggests that Sunrise has an extremely short storage life, and if any fruit is left at room temperature for a week, it would not be eatable. We believe that Sunrise is not a variety that should be grown commercially in New England because of uneven ripening on the tree and its limited storage potential.

The postharvest storage life of Paulared was similar to what we have learned to expect of this variety. It is a good McIntosh type to precede McIntosh on the market. However, after 6 weeks in storage, firmness dropped substantially, making these fruit a liability in the prime of McIntosh season. We believe that Paulared should be out of the storage and

sold at least by the middle of McIntosh season. Frequently, the quality of apples purchased from roadside stands is very high. Growers attempt to maintain this quality by harvesting fruit at optimum quality and store it appropriately in cold storage. Unfortunately, many consumers who purchase apples take them home and put them in a fruit bowl. One fact that this study vividly pointed out was that storing fruit at room temperature for 7 days, especially after storage, may result in excessive deterioration of the quality of fruit, and thus potentially influencing return sales of later maturing fruit.

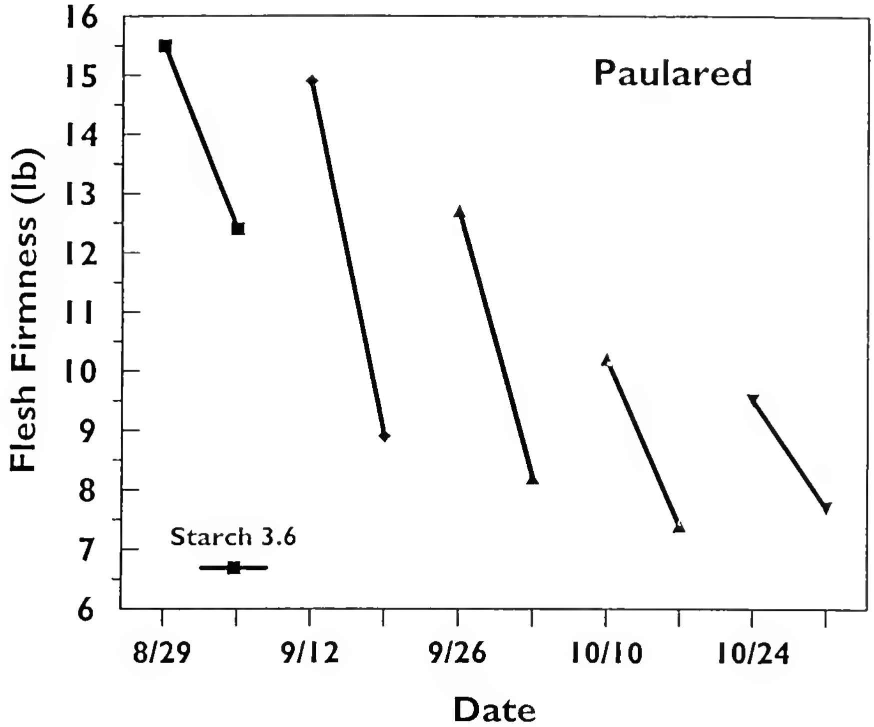

Figure 4. Flesh firmness of Paulared fruit immediately following 0 (at harvest), 2, 4, 6, and 8 weeks of storage at 32°F (represented by the first point of each line) and after 1 week at room temperature (represented by the second point of each

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Effects of Blossom Thinners on Peaches

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Peaches are thinned to increase fruit size, improve fruit quality, and reduce limb breakage. A number of physical methods have been devised to thin peaches including use of shakers, spraying of trees with a high-pressure stream of water, hitting limbs with rubber hoses or foam-covered sticks, and running ropes on a tractor-mounted frame through trees. No method of physically reducing crop load has been widely accepted due to variable or unsatisfactory responses.

The majority of fruit thinning on apples is done with chemicals that are applied after bloom. They cause thinning by either affecting hormone content or influencing carbohydrate distribution within rapidly developing fruit. Blossom thinner application may precede postbloom thinners so that less aggressive postbloom thinning is required. Unfortunately, all postbloom hormone-type thinners are ineffective on peaches. In recent years, several compounds have been report to reduce crop load on peaches when applied at or slightly before bloom. Among those chemicals most frequently evaluated are: endothall, pelargonic acid, sulfcarbamide, ammonium thiosulfate, and hydrogen cyanamide. There has not been universal acceptance of blossom thinners for use on peaches for several reasons. Some thinners have not been registered for use on fruit crops, results have been erratic and inconsistent, and there is a reluctance by growers to apply chemicals designed specifically to reduce fruit set before a crop has been set and initial crop load can be assessed.

Apples have been the primary crop grown by orchardists in New England, but the focus is changing due to global competition and low price. Increasingly, growers are decreasing their dependence on apples, reducing total acreage and diversifying into other crops, including peaches. Peaches can be a very lucrative crop, but only if large sized fruit are produced. Further, peaches are a more labor intensive crop, and labor requirements for hand thinning of peaches frequently coincides with cultural demands of apples. Therefore, there is intense grower interest in using blossom thinners to increase fruit size and to reduce the amount of time required to hand thin.

The purpose of this investigation was to evaluate the effects of the most promising blossom thinners on peaches. We also hoped to identify appropriate concentrations to use and to evaluate consistency of response.

Methods & Methods

Mature Garnet Beauty and Redhaven trees growing at the University of Massachusetts Horticultural Research Center in Belchertown were used in this investigation. Tree spacing was 17' x 24', giving a density of 107 trees per acre. Endothall, Wilthin, and ammonium thiosulfate (ATS) were evaluated in 1997, 1998, and 1999 on the same block of peach trees. Based upon phytotoxicity and thinner efficacy, thinner concentrations were adjusted yearly. Here, we are presenting 1999 data only, since we feel that the chemical concentration and timing of application are close to that which may ultimately be adopted for commercial application.

In each year, 18 Redhaven trees and 24 Garnet Beauty trees were blocked into three groups (replications) and four groups (replications), respectively, of six trees each. Within each replication trees were randomly assigned one of six treatments; control, two rates of Wilthin, two rates of ATS, and one rate of endothall.

In 1999, prior to the application of blossom thinners, three limbs on each tree, 10 to 12 cm in diameter, were tagged and measured. At the time of application, bloom on Garnet Beauty was estimated to be 60% open while that on Redhaven was judged to be 80% open. Treatments were applied on May 2 using a rear mounted airblast sprayer delivering 100 gallons of water per acre. Wilthin was applied at rates of 6 and 8 quarts per acre with 1 pint Regulaid per 100 gallons of spray. ATS was applied at 4 and 6 gallons per acre, and the endothall rate was 1.5 pints per 100 gallons. One tree per block was not sprayed and served as the control. Temperature at the time of application was

Table 1. Effects of Wilthin, endothall and ammonium thiosulfate (ATS) on fruit set, thinning required, and fruit size of Garnet Beauty and Redhaven peaches, 1999.

	Fruit/cm^2 limb cross-sectional area				
Treatment	Initial fruit set	Hand thinned off	Final set	Fruit weight (g)	Fruit diameter (in)
Control	25.7 a	18.8 a	6.9 a	136 d	2.51 d
Wilthin 6 qt/acre + 1 pt Regulaid	16.3 b	11.3 b	5.7 ab	151 cd	2.60 cd
Wilthin 8 qt/acre + 1 pt Regulaid	16.2 b	10.7 bc	5.5 ab	176 bc	2.73 bc
Endothall 1.5 pt/acre	14.8 b	8.5 bc	5.5 ab	184 b	2.79 b
ATS 4 gal/acre	10.9 bc	6.4 cd	4.5 bc	197 b	2.84 b
ATS 6 gal/acre	6.8 c	3.8 d	3.0 c	228 a	3.01 a

Means within columns not followed by the same letter are significantly different at odds of 19 to 1.

approximately 60°F with little wind, and by mid afternoon, the temperature had risen to the lower 70's. Initial set was determined by counting all persisting fruit on tagged limbs at the normal time for hand thinning, about 45 days after bloom, when fruit diameter averaged 1 inch. Hand thinning was done to a commercially acceptable level on each tagged limb, by spacing fruit to about 6 inches apart. The number of fruit hand thinned from each limb was counted and recorded. Initial fruit set, hand thinned fruit, and final set were calculated based upon the cross-sectional area of each limb. Ten fruit or the number of fruit ready for commercial harvest were sampled from the tagged limbs on July 23, 27, and 30 for Garnet Beauty, and on August 5, 10, and 12 for Redhaven. Harvested fruit were taken to the laboratory where they were weighed, the average fruit weight calculated, and then the diameter of each fruit measured with a hand-held fruit sizer.

Results

Blossom thinning treatments significantly reduced initial set and the number of fruit that needed to be removed by hand thinning (Table 1). ATS appeared to reduce initial set the most, although the 6-gallons-per-acre rate was the only one to reduce initial set and final set below that of endothall and Wilthin. Fruit weight and fruit diameter at harvest were increased by all blossom thinners. ATS increased fruit weight and diameter most dramatically, endothall was intermediate, while Wilthin had the smallest effect. The lowers rate of Wilthin, 6 quarts per acre, did not increase fruit weight or diameter relative to the control.

Discussion

One of the goals of this investigation was to identify concentrations of thinning chemicals that would consistently and effectively thin peaches. ATS caused excessive thinning, phytotoxicity, and shoot dyeback in 1997. Part of the response was due to the higher rate used than reported in other investigations. Another component was that the amount of spray deposited was increased in portions of the tree when the sprayer application was into the wind estimated to be 25 mph. Rates were lowered in 1998 and applications were made under favorable thinning conditions. Insufficient thinning was achieved at the low rate. Concentrations were again adjusted in 1999

to 4 and 6 gallons per acre, and application was made again under favorable thinning conditions. Based on these results we believe that consistent and effective thinning with ATS can be achieved if between 3 and 5 gallons per acre are applied in 100 gallons of water per acrer. The highest rate of endothall used was 1.5 pints per 100 gallon in 1999, and that seemed to thin appropriately. Wilthin was the weakest thinner used, and even when applied at 8 quarts per acre, which is, in general, higher than previously used, it was still a modest thinner at best.

The importance of blossom thinning at bloom to maximize fruit size at harvest has been recognized for many years. While thinning can be done if thinners are applied anywhere from pink to full bloom, the greatest response is when application is made near bloom. Thinners act by interfering with ovule fertilization, either by preventing successful pollination or by disturbing pollen tube growth. Results from this investigation suggest that timing of application may influence the thinners response. The best thinning results were obtained in 1999 when treatments were applied when blossoms were 65 to 80% open rather than closer to 100% which was the situation in the two previous seasons. If flowers open over a several-day period, especially under cool conditions, there may be ample opportunity for pollination and significant pollen tube growth of many flowers, before applications are made at full bloom .

It was observed that blossom thinners did not thin uniformly on the tagged limbs. There were some areas of the limb that set a less than optimal number of fruit, thus fruit were spaced more than 6 inches apart, whereas other areas were set heavier and require more hand thinning. The reduction in final set by ATS in 1999 documents that excessive thinning was done. Some hand thinning was also required on these same limbs indicating that there were also areas where fruit were clustered.

Successful blossom thinning treatments resulted in a reduction in hand thinning of between 50% to 80%. This reduction following blossom thinner use can translate into a significant labor savings. In general, it required about one hour to hand thin a control tree. At $7.50 per hour, the cost of hand thinning these trees would be about $800 per acre. A 50% to 80% reduction in hand thinning would be a savings of between $400 and $640 per acre.

Some of the blossom thinning treatments reported in this investigation resulted in a reduction in yield, as expressed by number of fruit per limb cross-sectional area. Fruit from these lower yielding trees may pay a grower more money than higher yielding hand-thinned control trees, because fruit on blossom thinned trees were larger, and higher prices are paid for larger fruit. There is little demand for a peach less than 2.5 inches.

We believe that blossom thinning of peaches in New England is a practice that can be reliably and very profitably used by growers. Key components for success include selection of the proper rate per acre of thinner to apply, application of the spray to mature plantings in 100 gallons per acre of water in an accurately calibrated sprayer, and spray in appropriate weather before most flowers are pollinated, generally before full bloom. In our estimation endothall and ATS hold the greatest commercial potential as blossom thinners on peaches.

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Comparison of Provado™ and Actara™ as Toxicants on Pesticide-treated Spheres

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As reported in previous issues of *Fruit Notes*, we believe that behavioral control using red spheres holds potential as an eventual replacement for use of insecticidal sprays against apple maggot flies (AMF). Toward this, we have developed pesticide-treated spheres, which are designed to kill alighting flies either by contact with or ingestion of a lethal dose of insecticide, which is bound in latex paint coating the sphere. Such an advance may alleviate the need for use of Tangletrap on spheres, which currently renders spheres too costly and laborious for wide-scale commercial use.

For spheres to become a viable alternative to chemical treatments for AMF control, we believe that four criteria must be met. Spheres must be:

1) easy and safe to deploy and maintain
2) as effective as insecticide sprays
3) able to endure through the 12-14 week AMF season
4) capable of maintaining fly-killing power with a very low dose of toxicant

Over the past 3 years, we have moved toward satisfying, but have not fully satisfied, all of the above criteria. Additional articles within this issue (see **Attracticidal Spheres**) highlight studies of the efficiency of various sphere types. Here, we present findings of a 1999 comparison of toxicants intended for use on spheres: imidacloprid (Provado) and thiamethoxam (soon to be labeled as Actara).

Materials & Methods

We formulated three rates each (2, 4, and 8%) of imidacloprid and thiamethoxam in latex paint and applied each mixture to 8-cm red wooden spheres (~3 grams per sphere). At each dose of each chemical, we prepared ten spheres, then subjected two spheres of each treatment to 0, 3, 6, 9, or 12 weeks of field exposure (encompassing the normal Massachusetts AMF season). For each treatment set, we also prepared and exposed two control spheres (treated with latex paint alone). In all, we used 70 wooden spheres in this experiment.

One set of spheres was retained in the laboratory for immediate testing (0 weeks field exposure) We placed all other spheres in a block of unsprayed, medium-sized Delicious apple trees on June 30. At 3-week intervals thereafter, we retrieved one set of 14 spheres for testing; spheres were removed from the field for assays on July 19 (3 weeks), August 10 (6 weeks), September 1 (9 weeks), and September 22 (12 weeks). Throughout the time of study, we recorded daily rainfall using a Campbell weather monitoring station.

Upon return to the lab, we performed two assays: exposure and subsequent mortality of flies on spheres without addition of feeding stimulant (yielding relative contact activity of toxicants) and exposure and mortality of flies on spheres after treatment with a 20% sucrose solution (yielding activity of toxicants after ingestion). We exposed thirty flies (individually) to each treatment, recorded time spent feeding or foraging on spheres, and assessed levels of fly mortality at 24, 48, and 72 hours post-exposure.

Results

Contact Toxicity (no feeding stimulant)

For spheres tested prior to weathering, exposure of flies to spheres treated with either chemical at any rate yielded mortality no higher than 45% (Figure 1). Subsequent tests of field-exposed spheres offered even lower contact toxicity (at all rates), with the exception of spheres exposed six weeks, which resulted in fly mortality nearly identical to unweathered spheres.

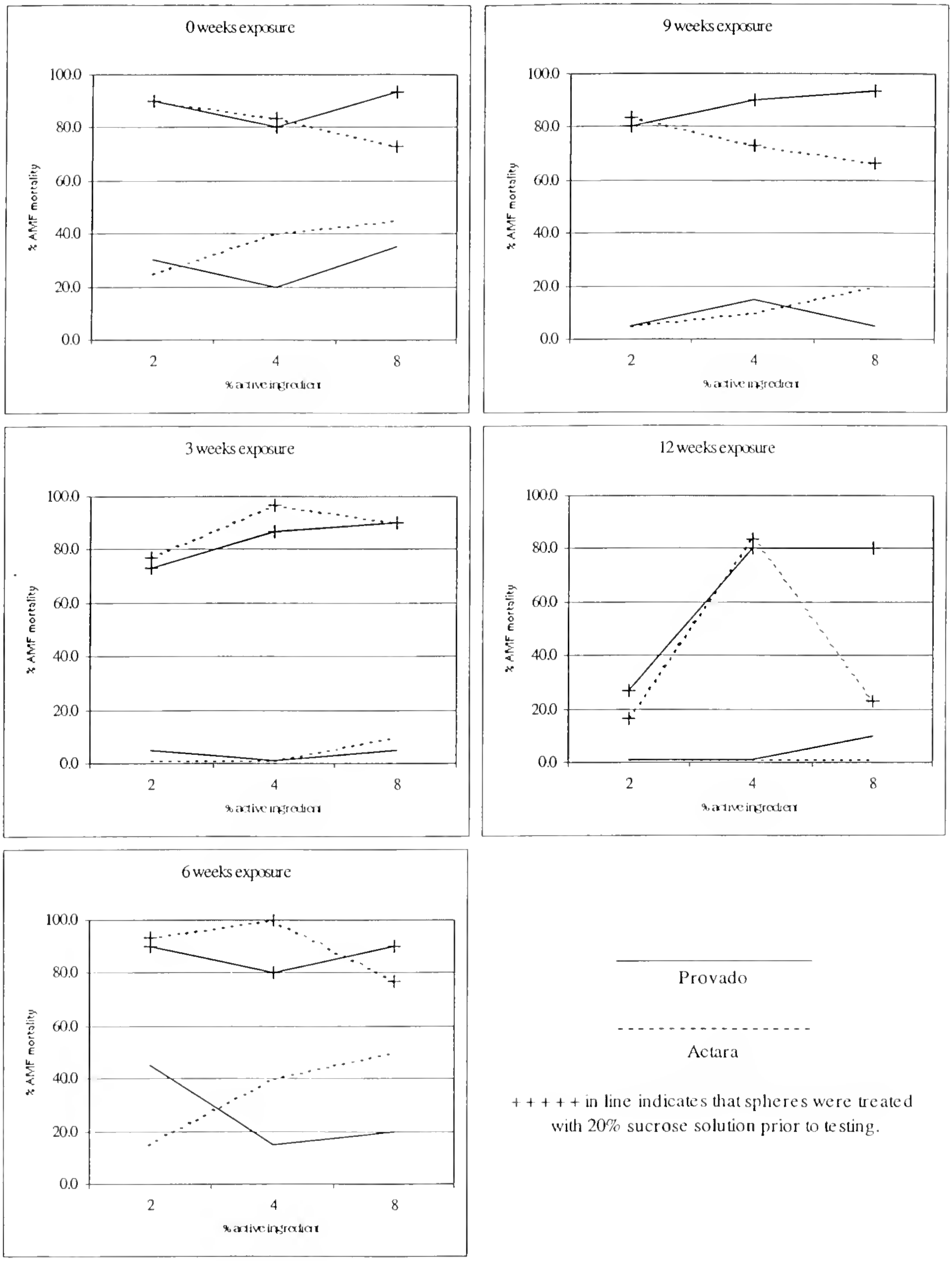

Figure 1. Mortality of apple maggot flies exposed to wooden pesticide-treated spheres subjected to 0, 3, 6, 9, or 12 weeks of field exposure after treatment with varying concentrations of insecticide. Flies were tested on spheres with or without sugar added to the surface prior to testing. Each point represents mortality of 30 tested flies.

Table 1. Period of exposure, sphere retrieval date, and cumulative rainfall during each testing interval.

Field exposure (wks)	Retrieval date	Cumulative rainfall exposure (inches)
0	June 30	0.0
3	July 19	1.4
6	August 10	2.1
9	September 1	6.1
12	September 22	17.0

Feeding Toxicity (20% sugar solution applied)

Before field exposure, spheres treated with either imidacloprid or thiamethoxam performed well, with both materials offering 90% kill of feeding AMF at the lowest dose (2%) (Figure 1). However, higher doses of each material did not necessarily correlate with greater efficiency. In fact, as the dose of thiamethoxam increased, fly mortality decreased.

Through nine weeks of field exposure, spheres treated with imidacloprid retained a high level of fly-killing power—offering levels of control nearly identical to fresh spheres. Spheres treated with thiamethoxam also exhibited good (77%) to excellent (100%) control at low and moderate doses, while mortality of flies exposed to the high dose began to decline steadily after three weeks of field exposure.

Disappointingly, the low rates of both materials faltered after twelve weeks of field exposure, as eleven inches of rain fell in the interval between nine and twelve weeks (Table 1). However, the moderate rates (4%) of imidacloprid and thiamethoxam maintained a reasonable level of fly-killing activity (80 and 83% control, respectively). At the high dose, imidacloprid retained toxicity through twelve weeks, while mortality after exposure to thiamethoxam dropped markedly.

Conclusions

Imidacloprid and thiamethoxam stem from the same chemical family (neonicotinoids), and are known to have similar modes of action and spectra of activity. Given this, it is not surprising to see that patterns of toxicity against foraging and feeding AMF on spheres were very similar for the two chemicals. It appears that the major difference between the two (for use on spheres) is the formulation. The flowable formulation of Provado (imidacloprid) mixes easily into paint and is retained nicely within the latex for slow release, even at relatively high doses (up to ~10% a.i.). Actara, on the other hand, is in a wettable granular formulation, and must be thinned in water (1:1) before introduction into the paint. Because of this, much more liquid must be added into the paint, leaving far less latex per sphere to retain the active ingredient. This is the probable cause of rapid loss of thiamethoxam activity at high doses under heavy rainfall.

It is clear from this study that pursuit of contact toxicity using either of these materials is fruitless. However, in the presence of feeding stimulant (sucrose), low doses of either material offers good AMF control through nine weeks of field exposure. Not surprisingly, under the extreme rainfall conditions of September, efficacy of these low doses declined. We are nonetheless encouraged by the performance of these materials on field-exposed spheres at low and moderate doses, and feel that either can be formulated to achieve our goal: reliable, safe control of flies throughout the 12-14 week AMF season.

Acknowledgements

We would like to thank Joe Sincuk of the University of Massachusetts Horticultural Research Center for contributing orchard space for sphere deployment. We are also grateful to our technical staff for preparing and maintaining spheres: Jonathan Black, Russell Fleury, and Susan Nixson. This work was supported by State and Federal IPM funds, the Horticultural Research Center Trust Fund, the Washington State Tree Fruit Research Commission, the Massachusetts Society for Promoting Agriculture, and the USDA CSREES Pest Management Alternatives Program.

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Commercial Orchard Trials of Attracticidal Spheres for Controlling Apple Maggot Flies

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For nearly a decade, we have been engaged in development and refinement of pesticide-treated spheres as a substitute for sticky-coated spheres for controlling apple maggot flies (AMF). This endeavor has given rise to two rather different types of pesticide-treated spheres.

The first type consists of a wooden sphere coated with a mixture of pesticide, latex paint (as a residue-extending agent for pesticide), and sucrose (as a feeding stimulant for alighting flies). Because we have been unable to find an effective residue-extending agent for sucrose (which is washed away during rainfall), we have taken an alternative route and attempted to re-supply sucrose to the sphere surface through placement of a cap of hardened sucrose on top of a sphere. Ideally, sucrose would distribute gradually from the cap onto the sphere surface during rainfall, leaving a film of ample feeding stimulant after drying.

The second type consists of a sphere whose body is comprised of a mixture of moistened sugar, flour, and glycerin. After drying, this type of spheres looks and feels as though it were a hardened ball of pie-dough. Under rainfall, sugar seeps through the coat of latex paint and pesticide applied to the sphere surface and ideally provides a continuous supply of feeding stimulant to the sphere surface.

Here, for each of 3 years, we compared the effectiveness of odor-baited pesticide-treated wooden spheres and odor-baited pesticide-treated sugar/flour spheres with that of odor-baited sticky spheres or insecticide sprays for controlling AMF in commercial orchards.

Materials & Methods

Tests were conducted in 1997, 1998, and 1999 in each of eight commercial apple orchards in Massachusetts. Each orchard contained four blocks of medium-sized apple trees (M.26 rootstock) comprised almost exclusively of the cultivars McIntosh and Cortland. Each block consisted of 49 trees in a seven x seven arrangement: seven perimeter-row trees and six successively internal rows of seven trees each. During the first week of July each year (i.e., just before AMF immigration), each of the 24 perimeter trees in three blocks per orchard received an odor-baited sphere. All spheres were red in color, 3 inches diameter, baited with a polyethylene vial containing synthetic fruit odor attractant (butyl hexanoate) and hung 2 to 3 yards above the ground from apple tree branches in a way that maximized visual apparency and attractiveness. None of the three blocks was treated with insecticide within the 3 weeks prior to sphere deployment and none received insecticide after sphere deployment. The fourth block in each orchard was treated by the grower with two or three sprays per year of azinphosmethyl or phosmet to control AMF.

For wooden spheres, the surface was treated once with red gloss enamel paint and then after drying, was overlaid with a mixture containing 70% of the same paint, 20% sucrose, and 10% Provado (containing 20% imidacloprid). Imidacloprid is just as toxic to apple maggot flies and just as durable in latex paint as dimethoate, the insecticide of choice for previous versions of pesticide-treated red spheres, and is safer than dimethoate for handling of treated spheres. Painted spheres were allowed to dry and then equipped with a disc (0.75 inch tall x 1.5 inches diameter) of caramelized (hardened) sugar affixed to the top of each sphere (Figure 1) In 1997, discs atop wooden spheres originated from a mixture of 61% sucrose, 17% fructose, and 22% water, which, after heating to 150°C, was poured into 0.75-by-1.5-inch moulds and allowed to cool and harden. It turned out, however, that such discs dissipated in rainfall or dew more quickly than desired. Therefore, in 1998, we used the same type of disc as in

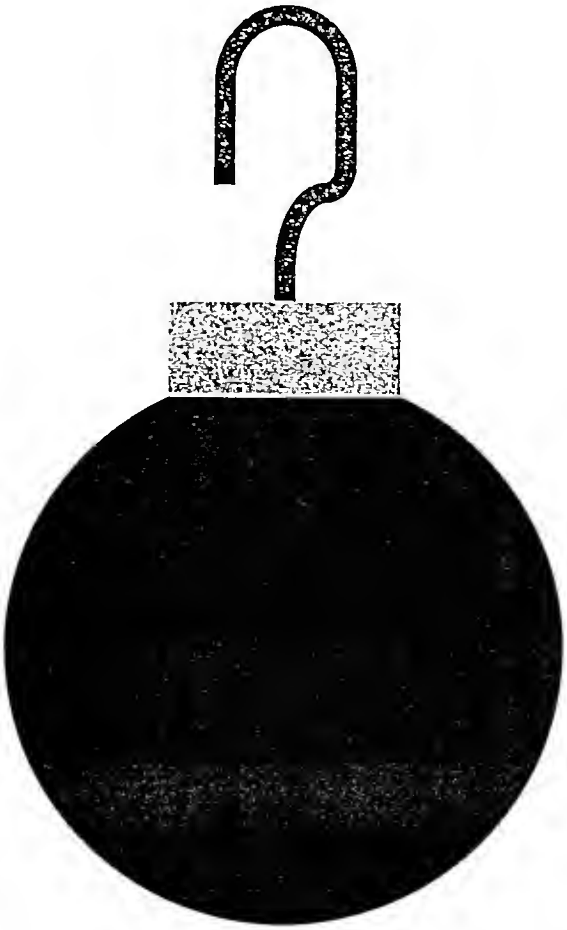

Figure 1. Schematic illustration of a wooden pesticide-treated sphere capped with a disc comprised of hardened sucrose.

1997 but placed each disc in an open 0.75-by-1.5-inch plastic Petri dish to extend residual amount available. Again, rainfall and dew caused too rapid a dissipation of discs. In 1999, discs were formed from a mixture of 15% paraffin wax and 85% sucrose. Wax and sugar were heated separately to 150°C until liquid and then blended. After cooling, the resulting granular mixture was compressed into a mould, where it hardened. No Petri dishes were used beneath discs in 1999. Residual amount of sugar available in discs after rainfall was much greater in 1999 than in 1997 or 1998. Discs atop spheres were replaced every 2, 4, and 6 weeks, respectively, in 1997, 1998, and 1999.

For sugar/flour spheres, ingredients of sphere bodies each year were very similar: 18% pre-gelatinized corn flour, 18% wheat flour, 22% granulated sucrose, 21% corn syrup (containing fructose), 7%glycerin, 8% water, 5% cayenne pepper (aimed at deterring rodents feeding on spheres), and 1% sorbic acid (an anti-microbial agent). Each sphere was formed by hand around a cord in the center and was dried in an oven for hardening. Drying time and temperature proved important to sphere durability under field conditions. In 1997, spheres were dried at 125°C for 48 hours, in 1998 at 140°C for 72 hours, and in 1999 at 200° C for 2 hours. Sphere durability improved successively each year, with spheres in 1999 maintaining integrity throughout the 3-month period of deployment provided they were not consumed by rodents.

After hardening, sugar/flour spheres received two coats of latex paint, as described for wooden pesticide-treated spheres. Each year, sugar/flour spheres were replaced once (at midseason). In 1997, and to a lesser degree in 1998, replacement was necessary primarily because of pre-mature crumbling of spheres following rainfall. Indeed, in both years, spheres should have been replaced more than once for complete continuity of sphere presence in orchard blocks. In 1999, there was little pre-mature crumbling but a greater amount of feeding by rodents, sometimes resulting in complete consumption of some spheres.

For sticky spheres, Tangletrap was applied to the sphere surface. Each sticky sphere was cleaned of all insects and debris every two weeks and retreated with Tangletrap (if necessary) to maintain fly capturing effectiveness.

To evaluate the success of each treatment in controlling AMF, we monitored comparative amounts of fly penetration into blocks by hanging one unbaited sticky-coated red sphere from each of four trees near the center of each block and counted captured flies every 2 weeks, at which time spheres were cleaned of insects and debris and retreated with Tangletrap if needed. In addition, every 2 weeks we examined ten fruit on each of ten randomly selected interior trees per block (20 fruit on each of ten trees at harvest) for oviposition punctures made by AMF. Fruit with suspected punctures were dissected to confirm larval presence.

Results

Assessment via captures of AMF on interior unbaited monitoring traps (Figure 2) showed that each year, significantly more flies were captured on moni-

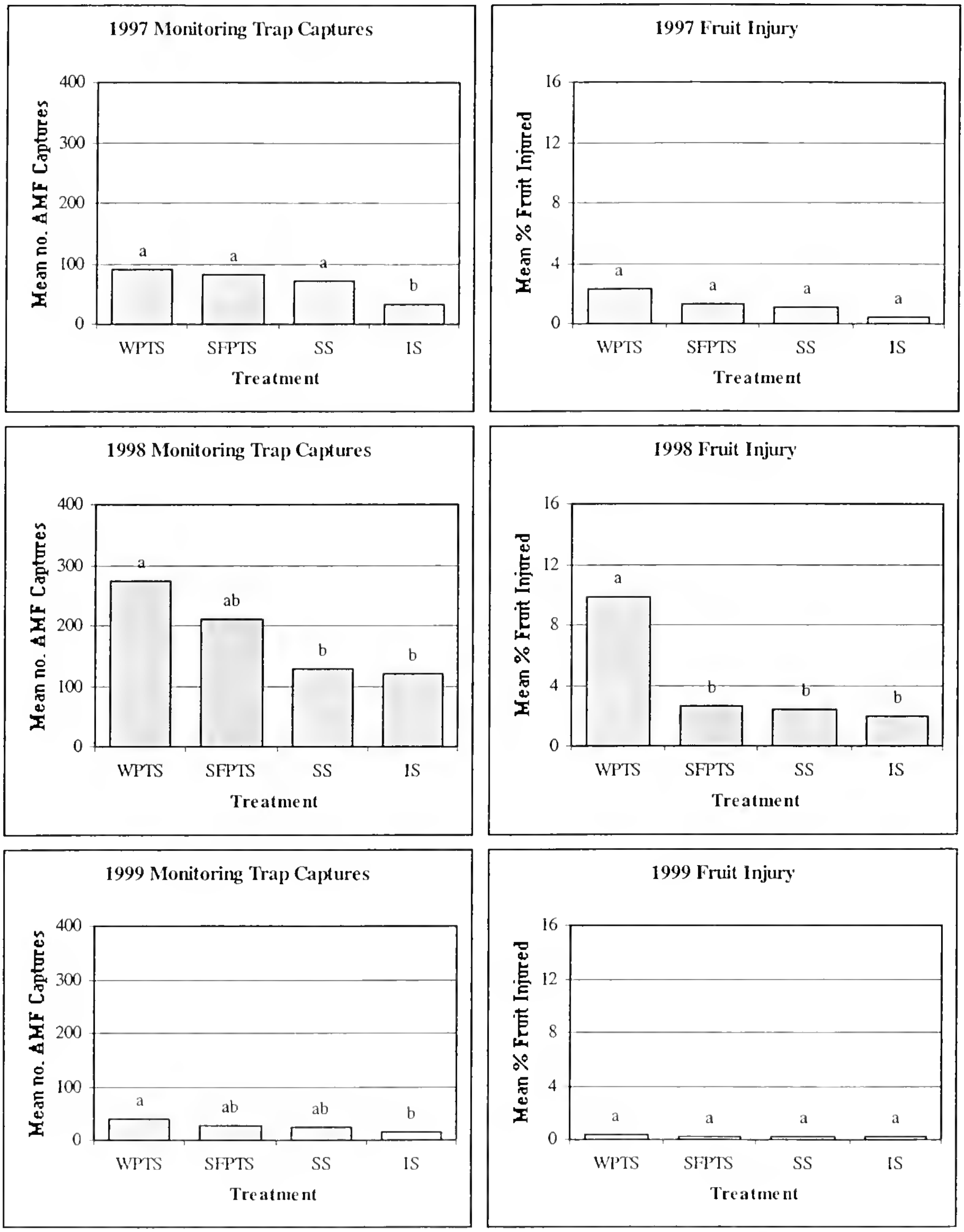

Figure 2. Mean number of apple maggot adults captured per block on interior unbaited monitoring traps and mean percent of fruit injured by apple maggot flies. Means superscribed by a different letter are significantly different at odds of 19:1. WPTS= wooden pesticide-treated spheres, SFPTS=sugar/flour pesticide-treated spheres, SS=sticky spheres, IS=insecticide sprays.

toring traps in blocks surrounded by wooden pesticide-treated spheres than in blocks sprayed with insecticide. In 1997, blocks surrounded by sugar/flour pesticide-treated spheres or sticky spheres likewise received significantly more flies on interior monitoring traps than did sprayed blocks, but there were no significant differences among these treatments in 1998 or 1999. Each year, the rank order (most to least) in which blocks received flies on interior monitoring traps was the same: wooden-pesticide treated spheres, sugar/flour pesticide-treated spheres, sticky spheres, and insecticide sprays.

Assessment via fruit injury by AMF (Figure 2) showed no significant differences among any of the four treatments for any year except 1998, when significantly more injury occurred to fruit in blocks surrounded by wooden pesticide-treated spheres than in blocks of any other treatment. Each year, the rank order (most to least) in which blocks received injury was the same: wooden pesticide-treated spheres, sugar/flour pesticide spheres, sticky spheres and insecticide sprays. The only exception was in 1999, when damage was low in all treatments and there was no numerical difference in injury among the latter three treatments.

Conclusions

Our findings revealed a consistent pattern in ability of odor-baited red spheres to intercept AMF and prevent injury to fruit. Each year, sticky-coated spheres were slightly less effective than insecticide sprays. Each year, sugar/flour pesticide-treated spheres were only slightly less effective than sticky-coated spheres, with comparative effectiveness essentially equal in 1999. Each year, wooden pesticide-treated spheres were less effective than sugar/flour pesticide treated spheres, with comparative effectiveness being similar in 1999.

It is gratifying that 1999 versions of wooden and sugar/flour pesticide-treated spheres were more effective (relative to sticky spheres and insecticide sprays) than 1997 or 1998 versions. Even so, further improvements are needed. In the case of wooden pesticide-treated spheres, an improved disc of wax and sucrose atop spheres is needed to ensure a continuous replenishing of sucrose to the sphere surface over the entire 3-month season of sphere deployment. In the case of sugar/flour pesticide-treated spheres, there is need for an inexpensive and more effective substitute for cayenne pepper for deterring feeding on spheres by rodents. Cayenne pepper is prohibitively expensive at concentrations greater than the 5% concentration used here, which was ineffective. There is also need for the private firm (Fruit Sphere Inc.) that has recently contracted to manufacture sugar/flour spheres to do so using an extruder and/or injection moulder so as to produce affordable spheres that are more uniform in shape, size, and hardness than the spheres used here, which were formed by hand. Ideally, manufactured sugar/flour spheres would remain completely intact until autumn or winter, when freezing would cause breakdown and disintegration.

Before improved versions of wooden or sugar/flour pesticide-treated spheres can be recommended for broad usage as a substitute for insecticide sprays to control AMF, such spheres need to be evaluated in larger blocks of apple trees than used here and deployment patterns of spheres need to be optimized so as to minimize the number of spheres per acre needed to achieve reliable control. Factors such as composition and arrangement of cultivars within orchard blocks, tree size, and fruit color and density can affect degree of sphere apparency to AMF, and hence can have a strong bearing on the number and arrangement of spheres needed for behavioral control.

Acknowledgements

We thank the growers who allowed us to conduct this research in their orchards: Wayne Rice, Dave Shearer, Tim Smith, Tony Lincoln, Joe Sincuk, Bill Broderick, Dave Chandler, and Dana Clark. We also thank Baruch Shasha, J.L. Willet, and R.W. Behle for assistance in constructing pesticide-treated spheres in 1997, The Biotechnology Research and Development Corporation for producing spheres used in 1999, and Bradley Chandler and Stephen Lavallee for assistance in evaluating sphere performance in orchards. This work was supported by grants from the Massachusetts Society for Promoting Agriculture, the Massachusetts Department of Food & Agriculture, the USDA CSREES Pest Management Alternatives Program, the USDA SARE Program, and the Washington State Tree Fruit Research Commission.

* * * * *

Effects of Tree Size and Planting Density on Control of Apple Maggot Flies with Odor-baited Red Spheres

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There is an increasing tendency among New England apple growers to replace trees on semidwarf rootstocks with dwarf trees. Although this has clear advantages from the orchard-management perspective, little is known about the impact of this horticultural practice on pest control. Behavioral control of apple maggot fly (AMF), a key pest of apples in Massachusetts, relies on interception of females immigrating into orchards using sticky red spheres. Female AMF are intercepted by traps placed on perimeter trees before they can penetrate and cause damage to fruit within the orchard.

It is a widely known fact that some insects modify their behavior on plants of different sizes. It is conceivable then, that changes in AMF behavior on apple trees of different sizes could affect their response to interception traps and result in more or less fruit damage.

As part of a study encompassing the effect of tree size on all IPM practices in apple orchards, we studied the effect of tree size and planting density on control of AMF using odor-baited red spheres.

Materials & Methods

We conducted experiments during the growing seasons of 1997, 1998, and 1999 in eight commercial orchards in Massachusetts. In each of the orchards, we selected six square blocks of apple trees, two each of small, medium, and large trees (M.9, M26, and M.7 rootstock, respectively). All blocks consisted of seven rows of McIntosh and/or Cortland trees perpendicular to the hedgerow or woods at the orchard margin (Figure 1). All blocks in every orchard were sprayed until early June to control insects and diseases. Thereafter, one block of each tree size in each orchard received odor-baited traps hung on perimeter trees every 6 yards to intercept immigrating flies (IPM blocks). The other three blocks received insecticide to control AMF (control blocks). To compare populations of flies inside IPM and control blocks, we placed four unbaited spheres near the center of each block and counted the number of flies captured by those spheres every 2 weeks. Fruit injury was compared by sampling 20 fruit on 10 trees at the interior of each block every 2 weeks.

Additionally, we released flies marked with different colors at the interior and exterior of IPM blocks of different tree sizes. Marked flies released inside blocks allowed us to determine the fate of flies that are able to penetrate IPM blocks, whereas flies released outside blocks permitted us to assess to what extent immigrating flies are intercepted by perimeter traps before entering IPM blocks of different tree sizes.

Results

To compare results in IPM and control blocks, we calculated the ratio of wild AMF captures by interior monitoring spheres in IPM vs. control blocks. Ratios were greater than one for all block types in 1997 and 1998, indicating slightly greater captures of wild AMF by monitoring traps in IPM blocks (Figure 2). Ratios were highest for large trees, although this pattern did not hold during 1999. Injury to fruit was less in IPM blocks than in control blocks of small trees whereas the reverse was true for blocks of large trees (Figure 3).

Marked AMF released inside blocks were recovered in larger percentages by perimeter traps in IPM blocks of small and medium sized trees than by those in blocks of large trees in 1997 (Figure 4). In 1998, there was no detectable pattern in recovery of released AMF. For marked AMF released outside of IPM blocks, more AMF were intercepted by perimeter traps

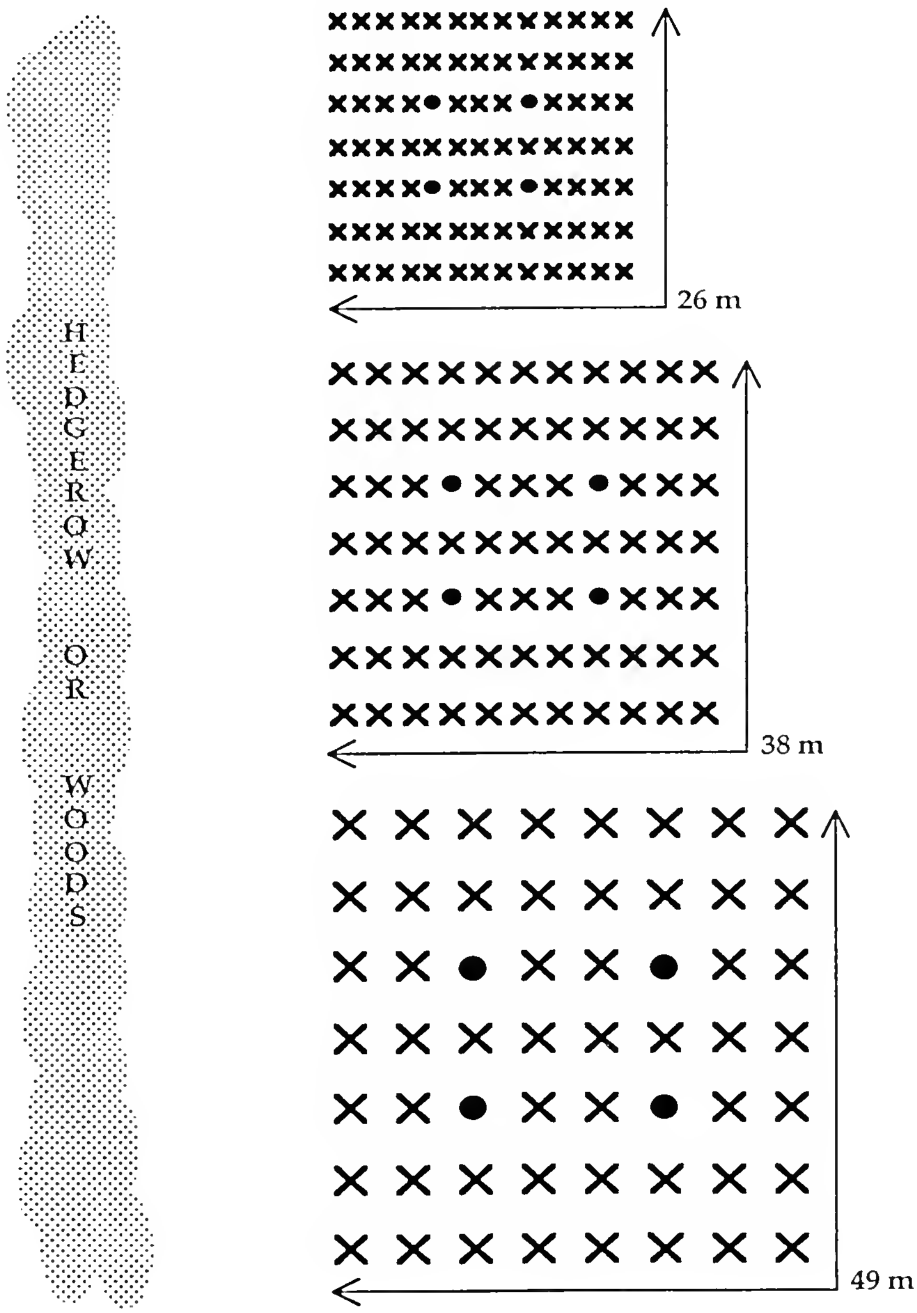

Figure 1. Illustration of IPM and control blocks of small, medium, and large trees (all blocks were comprised of seven rows). Circles indicate the position of interior monitoring traps.

on trees in the line of traps nearest to woods or hedgerows when those traps were placed on small trees than when they were placed on medium sized and large trees (Fig.5).

Conclusions

The level of AMF control provided by odor-baited spheres and insecticide sprays was roughly comparable

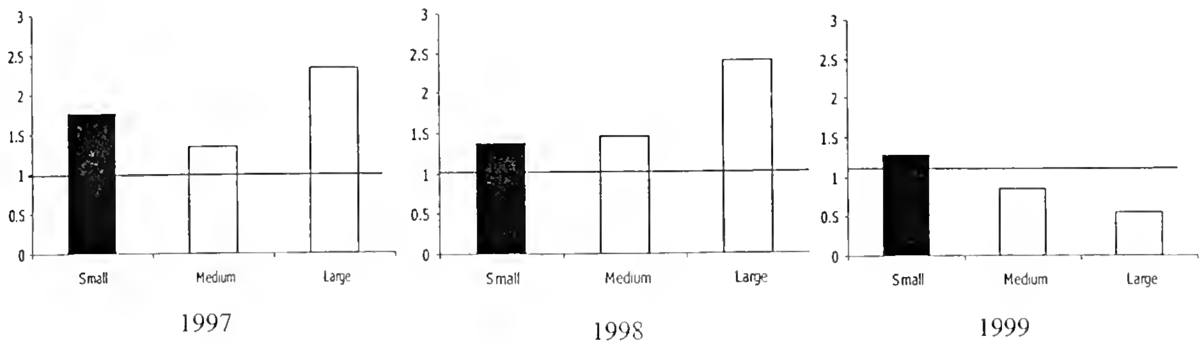

Figure 2. Ratios of the number of AMF captured on unbaited interior monitoring traps in IPM blocks:control blocks. Small, medium, and large refer to the tree size category.

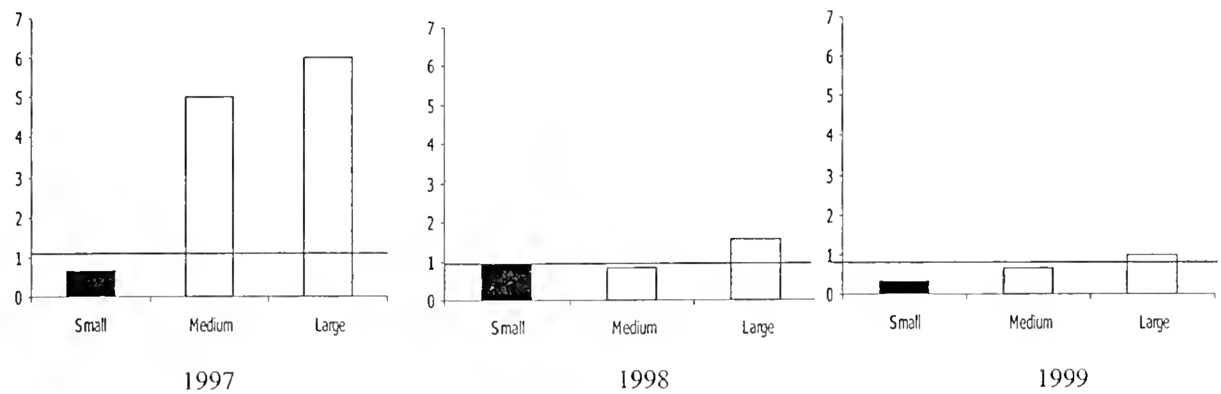

Figure 3. Ratios of the percent fruit injury by AMF in IPM blocks:control blocks. Small, medium, and large refer to the tree size category.

for all tree sizes. Although more AMF were caught by interior traps in IPM blocks in comparison to control blocks of each tree size, injury was slightly lower for fruit sampled in IPM blocks composed of small trees. Our results for wild AMF suggest that the level of control provided by red sphere traps increases when traps are placed on small trees. This view is further supported by the fact that we recovered more marked AMF on traps in blocks of small trees. Perhaps this was because those traps were more apparent to fruit-searching AMF on trees that have less leaf canopy volume. As a consequence, flies immigrating into IPM blocks will have a higher probability of being intercepted by traps placed on small trees when compared to the probability of being intercepted by traps on large trees.

Together, our results suggest that the trend among New England growers in adopting smaller tree sizes aids in maximizing the effectiveness of odor-baited spheres for controlling AMF.

Acknowledgments

We are thankful to William Broderick, David Chandler, David Cheney, Dana Clark, David Shearer, Joseph Sincuk, Timothy Smith, and Mo Tougas for generously allowing us to use their orchards. This work was supported by grants from the Massachusetts Department of Food and Agriculture, the USDA CSREES Pest Management Alternatives Program, USDA NRI grant 95-37313-1890, and the USDA SARE program.

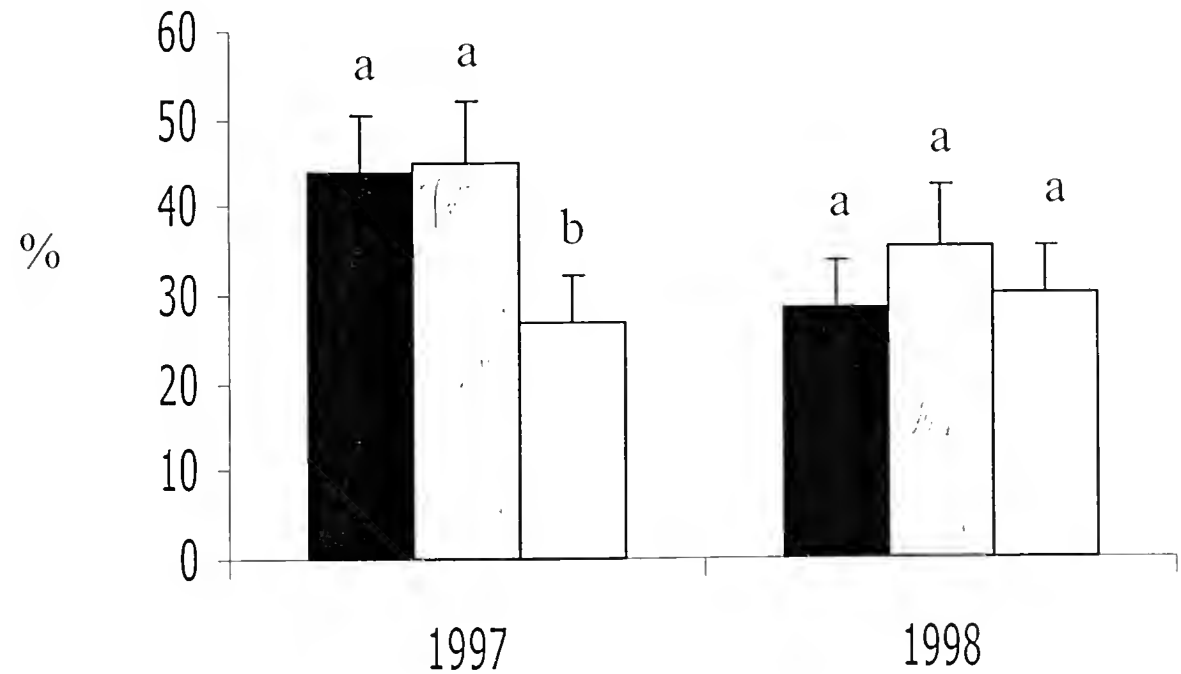

Figure 4. Percent recovery by baited perimeter traps of apple maggot flies released inside IPM blocks of small (black bar), medium (gray bar), and large (white bar) trees.

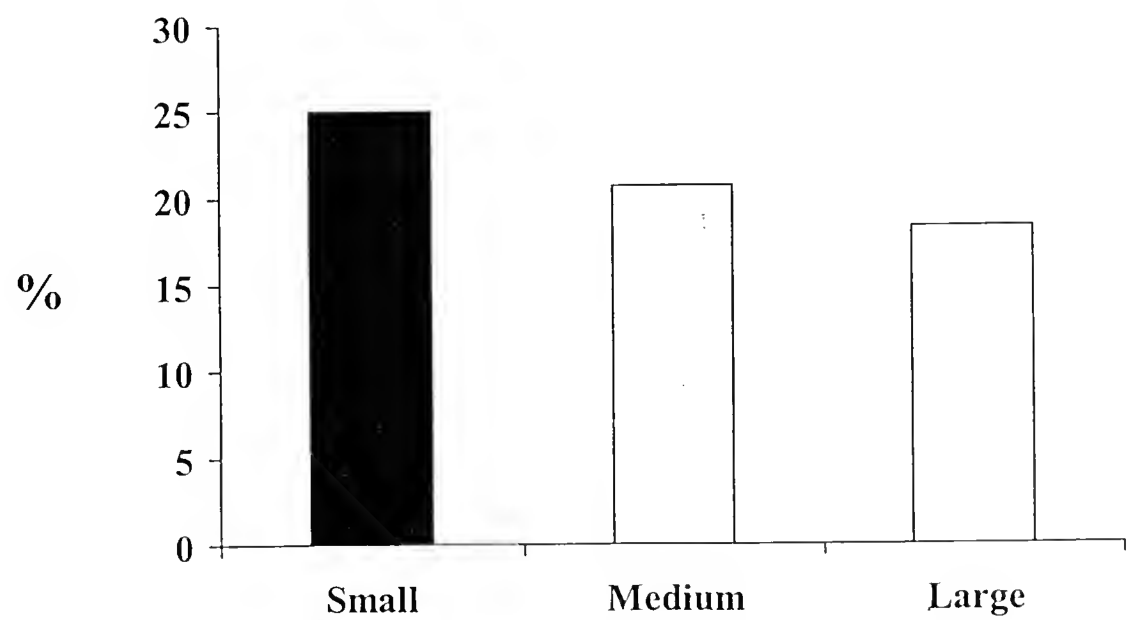

Figure 5. Percent recovery by baited perimeter traps of apple maggot flies released outside IPM blocks of small, medium, and large trees.

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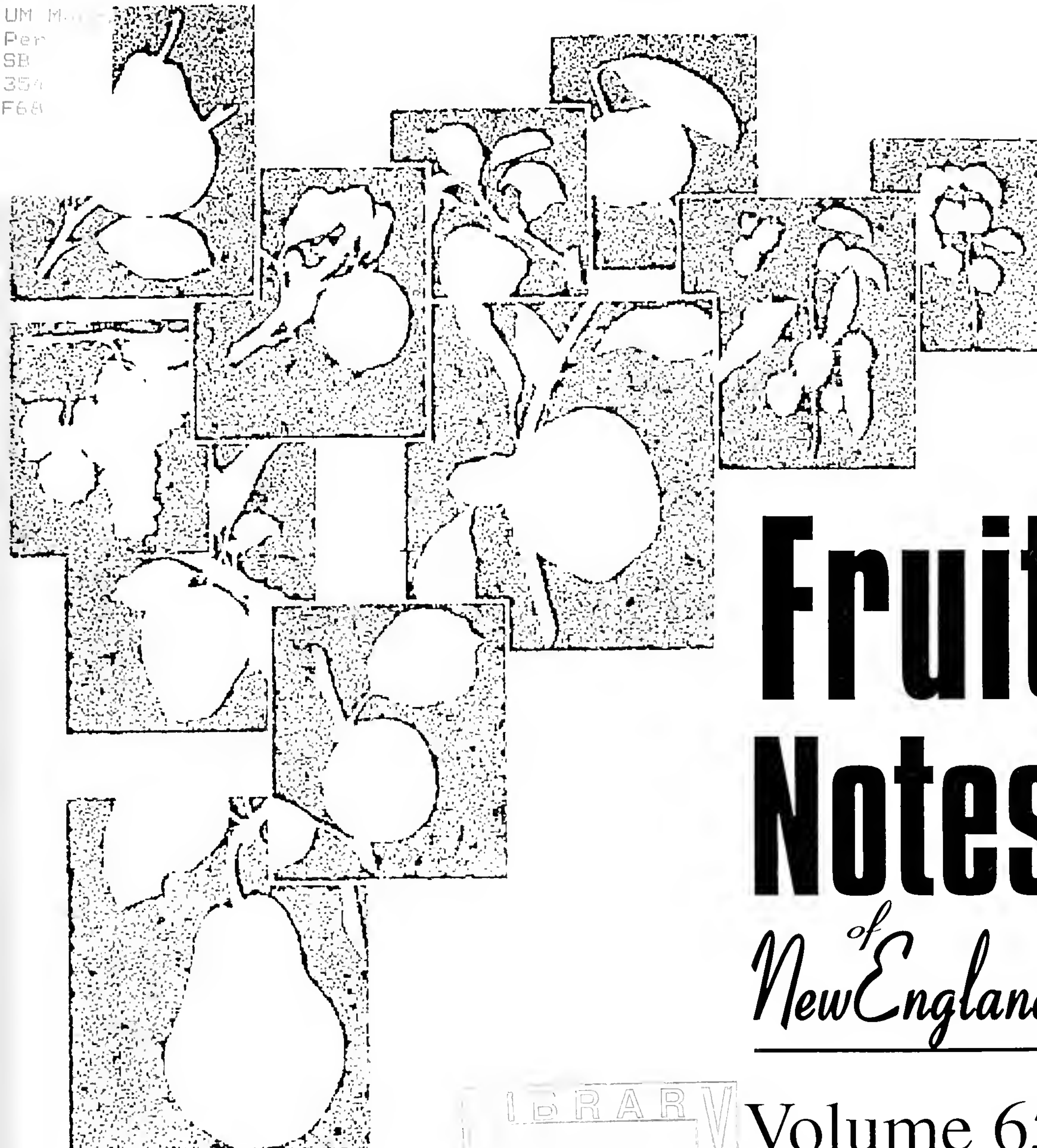

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Performance of Trees in the Massachusetts Planting of the 1994 NC-140 Apple Rootstock Trial over Seven Growing Seasons

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Over the last several years, the cost of producing apples has continued to increase, while returns have remained the same or increased only modestly. To remain profitable, apple growers must search out and adopt any efficiencies possible. One such efficiency is the use of dwarfing rootstocks. Fully dwarf rootstocks result in trees ranging from 10% to 40% of a standard, seedling-rooted tree. Compared to standard or semidwarf trees, these smaller trees produce similar or greater yields per acre, generally have larger fruit size and better color, require less pruning and harvest labor, and greatly reduce the amount of pesticides required to treat an acre. On the other hand, dwarf trees must be planted at significantly higher densities than semidwarf or standard trees, therefore they cost much more per acre to establish. This increased cost must be offset by the use of the optimum rootstock and planting density for a given condition so as to reduce the risk of inefficiency. Selecting the best rootstock is not always easy, since several dwarf rootstocks are now commercially available.

To aid growers in making these decisions, the NC-140

Table 1. Trunk cross-sectional area, suckering, yield, yield efficiency, and fruit weight in 2000 of Gala trees on several rootstocks in the Massachusetts planting of the 1994 NC-140 Apple Rootstock Trial.[z]

Rootstock	Trunk cross-sectional area (cm^2)	Root sukers (no./tree, 1994-2000)	Yield per tree (kg) 2000	Yield per tree (kg) Cumulative (1996-2000)	Yield efficiency (kg/cm^2 TCA) 2000	Yield efficiency (kg/cm^2 TCA) Cumulative (1996-2000)	Fruit weight (g) 2000	Fruit weight (g) Average (1996-2000)
M.9 EMLA	35.8 def	5.6 bcd	57 ab	132 bcdef	1.66 a	3.85 abc	150 a	169 abcd
M.26 EMLA	53.8 ab	1.0 d	60 ab	151 abcd	1.13 bcde	2.94 c	151 a	165 abcde
M.27 EMLA	9.3 j	3.8 cd	13 f	35 jk	1.31 abcde	3.90 abc	147 a	140 gh
M.9 RN29	42.7 bcd	12.9 abcd	64 a	159 abc	1.45 abcd	3.68 abc	158 a	179 a
M.9 Pajam 1	40.0 cde	13.7 abcd	55 ab	135 bcdef	1.42 abcd	3.45 abc	154 a	173 abc
M.9 Pajam 2	49.5 abc	23.0 a	67 a	168 ab	1.38 abcd	3.44 abc	148 a	180 a
B.9	27.1 efgh	7.0 bcd	40 bcde	96 efghi	1.45 abcd	3.62 abc	147 a	164 abcdef
B.491	12.7 ij	3.6 cd	19 ef	53 ijk	1.55 abc	4.21 ab	148 a	151 defgh
0.3	34.0 def	17.2 abc	53 ab	144 abcde	1.55 abc	4.37 a	147 a	160 bcdef
V.1	61.8 a	10.5 abcd	51 abc	191 a	0.85 e	3.17 bc	159 a	175 abc
P.2	34.6 def	3.4 cd	40 bcde	111 cdefgh	1.15 abcde	3.21 bc	151 a	162 abcdef
P.16	16.3 hij	24.2 a	24 def	68 hijk	1.47 abcd	4.12 ab	150 a	157 cdefg
Mark	25.1 fghi	10.8 abcd	27 cdef	86 fghij	1.06 cde	3.44 abc	136 ab	148 efgh
P.22	6.9 j	4.5 cd	7 f	23 k	0.99 de	3.36 abc	116 b	133 h
B.469	19.1 ghij	5.3 bcd	23 def	74 ghij	1.20 abcde	3.88 abc	133 ab	146 fgh
M.9 Fleuren 56	28.4 efgh	21.2 ab	46 abcd	106 defgh	1.68 a	3.83 abc	151 a	177 ab
M.9 NAKBT337	32.2 defg	9.2 abcd	52 abc	119 cdefg	1.63 ab	3.72 abc	156 a	178 a

[z] Means not followed by the same letter are significantly different at odds of 19 to 1.

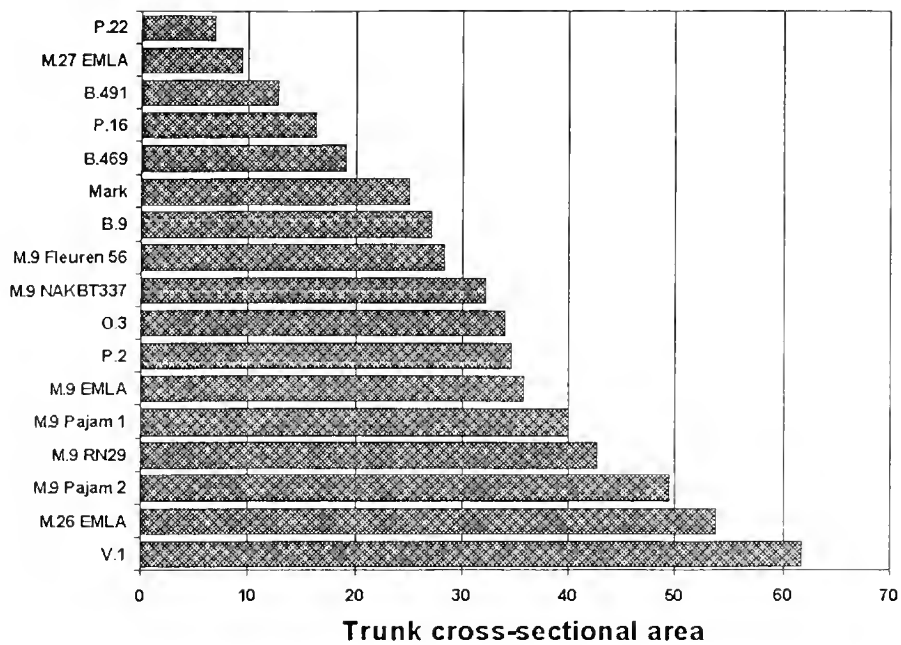

Figure 1. Trunk cross-sectional area (cm^2) of Gala trees on several rootstocks in the Massachusetts planting of the 1994 NC-140 Apple Rootstock Trial.

Technical Committee evaluates fruit-tree rootstocks throughout North America. A recent trial was established in 1994 at about 25 locations in the United States and Canada. It included Gala apple on 17 dwarfing rootstocks. Tree size (measured as trunk cross-sectional area), the number of root suckers, yield, and fruit size are assessed for each tree each year. Cumulative data from the first seven growing seasons of the Massachusetts planting of this trial are included in this article.

Trunk cross-sectional area is a universally used method to compare tree size of different treatments. It relates directly to the size of the canopy, and therefore allows a rough comparison of relative planting density. Even though all of the rootstocks included in this trial are considered dwarf, the trunk cross-sectional area varies greatly, from 6.9 cm^2 for trees on P.22 to 61.8 cm^2 for trees on V.1 (Table 1, Figure 1). These results show that P.22, M.27 EMLA, B.491, P.16, and B.469 likely are of little value, except with the very most vigorous varieties. Even with Gala (a relatively vigorous variety), these trees undoubtedly will "runt out" before the end of the trial. On the other end of the spectrum, V.1 produces a tree larger than does M.26 EMLA, and could be moved to the semidwarf category.

It is particularly interesting to compare the M.9 clones. Six are included in this trial, and they produce different sized trees. Trees on M.9 Pajam 2 had nearly twice the trunk cross-sectional area of trees on M.9 Fleuren 56 after seven seasons. The following M.9 clones are ordered from largest trees to smallest: M.9 Pajam 2 > M.9 RN29 > M.9 Pajam 1 > M.9 EMLA > M.9 NAKBT337 > M.9 Fleuren 56. This range of tree sizes suggests that growers planting trees on M.9 rootstock must be careful to know which clone they are purchasing and plan spacing of the trees accordingly.

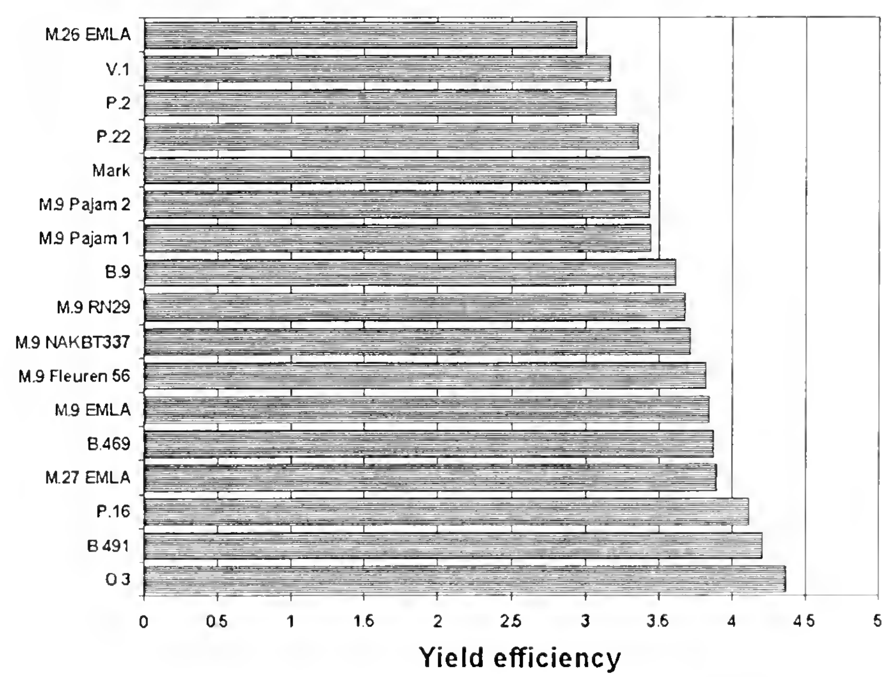

Figure 2. Yield efficiency (kg/cm^2 trunk cross-sectional area) of Gala trees on several rootstocks in the Massachusetts planting of the 1994 NC-140 Apple Rootstock Trial.

The most planted apple rootstock of the 1970's and 1980's, M.7, produces large numbers of root suckers. Growers tolerated this level of suckering, because M.7 resulted in a well-adapted, productive tree that was a dramatic improvement over seedling-rooted trees. Rootstocks which result in fully dwarf trees generally do not produce root sucker to anywhere near the extent that M.7 does. In this trial, M.9 Pajam 2 and P.16 generated the greatest number of root suckers, 23 and 24 per tree, respectively, in seven years (Table 1). Because of expected planting density, this level suckering would be a problem with P.16, possibly resulting in as many as 5,000 suckers per acre per year. Levels seen with other rootstocks likely would not present significant practical problems.

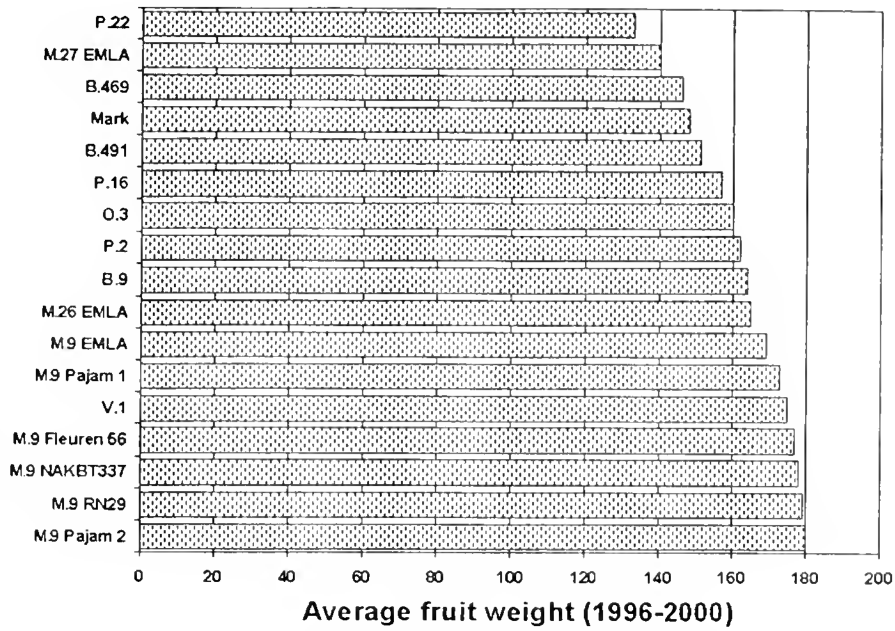

Figure 3. Average fruit size (g) from 1996-2000 from Gala trees on several rootstocks in the Massachusetts planting of the 1994 NC-140 Apple Rootstock Trial.

Obviously, yield is a major consideration when assessing rootstock performance. Actual yield per tree, however, is misleading. In this study (Table 1) as in many others, the yield per tree is more closely related to tree size than to rootstock directly. The ultimate assessment would be yield per acre, but that would require conducting an experiment first to determine tree size then a second experiment to compare rootstocks with each combination planted out at an appropriate spacing relative to tree size. Neither resources nor time are available to allow this approach. So, it is customary to use yield efficiency to relate yield to tree size. The relative differences in yield efficiency among rootstocks may reflect differences in potential yield per acre. Cumulative yield efficiency (1996-2000) does not vary greatly in this trial (Table 1, Figure 2). Very few statistically significant differences exist. It is possible to suggest that trees on O.3, B.491, and P.16 are more yield efficient than trees on M.26 EMLA. Also, trees on O.3 are more efficient than those on V.1 or P.2. Otherwise, the bulk of the rootstocks result in similarly efficient trees.

Fruit size can be affected by rootstock. In this trial averaged over all cropping years, size varied from just smaller than 100-count fruit (190 g) to just larger than 160-count fruit (120 g). Generally, the rootstocks that would be considered to have poor performance because of small fruit size were P.22, M.27 EMLA, B.469, Mark, B.490, and P.16. These are also the most dwarfing rootstocks. Generally, the M.9 clones resulted in the largest fruit over the five fruiting years of this study.

This study will conclude after three more seasons, but we can make some conclusions at this point:

1. P.22, M.27 EMLA, B.491, P.16, B.469, and Mark result in relatively weak trees that produce small fruit. It is likely that these rootstocks should be avoided except with the most vigorous scion cultivars.

2. Among the remaining rootstocks, yields per acre from appropriately spaced plantings will be similar.

3. M.9 continues to be a solid performer. Yield is good, and fruit size consistently is among the highest. It is important to understand differences among M.9 clones, however. Most of these differences relate to tree vigor. Trees on the most dwarfing M.9 clone (Fleuren 56) have about half the trunk cross-sectional area of trees on M.26 EMLA after seven growing season. Whereas, trees on the most vigorous M.9 clone (Pajam 2) are nearly as large as those on M.26 EMLA.

* * * * *

Performance of Trees in the Massachusetts Planting of the 1994 NC-140 Peach Rootstock Trial over Seven Growing Seasons

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Peaches are an increasingly important crop for farmstand sales in southern New England. Generally, returns are very good, but labor inputs are high, particularly for pruning and hand thinning. Some work is underway to address both of these issues. Duane Greene and Jim Krupa are working on thinning chemicals to reduce the amount of hand thinning required, and Jon Clements is beginning to study alternative training schemes that may reduce pruning costs. Although not likely to affect thinning needs, rootstocks may be another means of reducing pruning costs.

Only recently have researchers begun to evaluate rootstock material for peaches. Since the mid 1980's, the NC-140 Technical Committee has completed one trial, planted a second, and is planning a third. The second trial includes a number of rootstocks in about 20 locations and was established in 1994. Little interest exists in dwarfing rootstocks in much of the Country, but some of the material in this trial provide size control. The primary objective of the Massachusetts planting is to evaluate these rootstocks for dwarfing potential.

Table 1. Trunk cross-sectional area, yield, yield efficiency, and fruit weight in 2000 of Redhaven peach trees planted in Massachusetts as part of the 1994 NC-140 Peach Rootstock Trial.[z]

Rootstock	Trunk cross-sectional area (cm^2)	Yield per tree (kg) 2000	Yield per tree (kg) Cumulative (1996-2000)	Yield efficiency (kg/cm^2 TCA) 2000	Yield efficiency (kg/cm^2 TCA) Cumulative (1996-2000)	Fruit weight (g) 2000	Fruit weight (g) Average (1996-2000)
Lovell	130 a	34 a	176 ab	0.27 a	1.42 b	248 a	208 a
Bailey	101 ab	34 a	156 abc	0.36 a	1.63 ab	295 a	216 a
TN281-1	110 ab	38 a	177 a	0.35 a	1.63 ab	278 a	207 a
Stark's Redleaf	101 ab	35 a	174 ab	0.35 a	1.75 ab	311 a	221 a
GF305	102 ab	30 a	160 ab	0.29 a	1.60 ab	258 a	204 a
Higama	107 ab	31 a	161 ab	0.29 a	1.50 ab	248 a	191 a
Montclar	116 a	33 a	147 abc	0.29 a	1.30 b	251 a	195 a
Rubira	75 bc	24 a	135 abc	0.31 a	1.81 ab	263 a	205 a
Ishtara	56 c	23 a	110 c	0.42 a	2.00 a	230 a	192 a
H7338019	85 bc	31 a	146 abc	0.35 a	1.69 ab	270 a	206 a
BY520-8	100 ab	35 a	144 abc	0.36 a	1.45 ab	264 a	200 a
Guardian	130 a	34 a	169 ab	0.27 a	1.35 b	237 a	191 a
TaTao5/Lovell	97 ab	27 a	123 bc	0.27 a	1.26 b	218 a	192 a

[z] Means not followed by the same letter are significantly different at odds of 19 to 1.

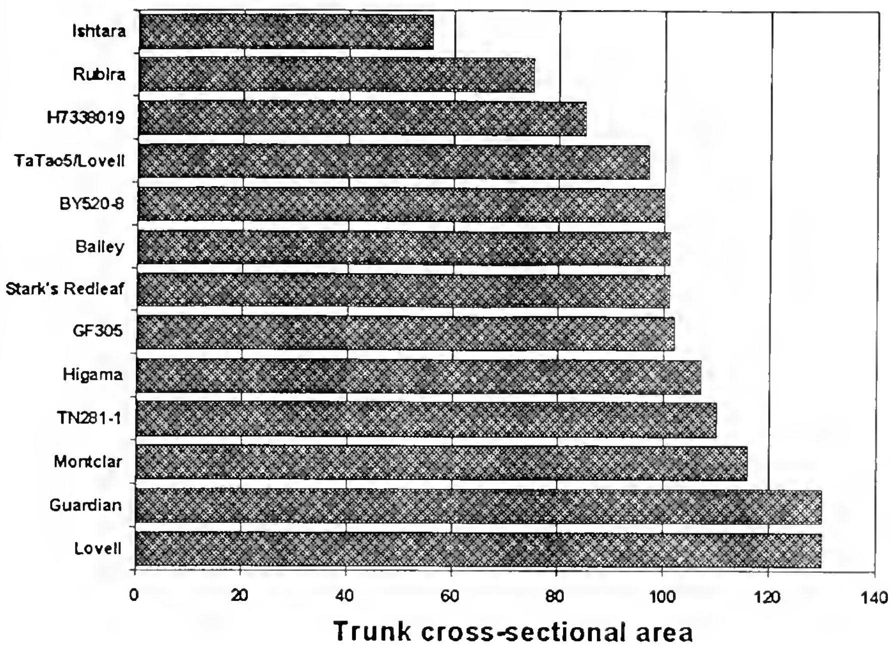

Figure 1. Trunk cross-sectional area (cm^2) of Redhaven trees on several rootstocks in the Massachusetts planting of the 1994 NC-140 Peach Rootstock Trial.

As noted in the previous article, trunk cross-sectional area is a universally used method to compare tree size of different treatments. It relates directly to the size of the canopy, and therefore allows a rough comparison of relative planting density. Most of the 13 rootstocks in this trial produce a tree that could be considered standard sized (Table 1, Figure). Trees on Guardian and those on Lovell were the largest in this category, but not significantly larger than those on TaTao5/Lovell, By520-8, Bailey, Stark's Redleaf, GF305, Higama, TN281-1, or Montclar. Trees on Ishtara, Rubira, and H7338019 were significantly smaller than those on Lovell or Guardian, and trees on Ishtara were significantly smaller than all other except those on Rubira or H7338019. The size of trees on Ishtara is strikingly smaller than that of the others, and these trees required significantly less time to prune.

Yield per tree (Table 1) was directly related to tree size, but the ultimate assessment would be yield per acre. Because resources and time are not available to conduct accurate assessments of real yield potential per acre, it is customary to use yield efficiency to relate yield to tree size. The relative differences in yield efficiency among rootstocks may reflect differences in potential yield per acre. Cumulative yield efficiency (1996-2000) did not vary greatly in this trial (Table 1). Trees on Ishtara, however were significantly more yield efficient than those on Lovell, Guardian, Montclar, or TaTao5/Lovell.

Fruit size can be affected by rootstock; however, rootstock did not affect fruit size in this trial in 2000 or on average from 1996-2000 (Table 1).

This study will conclude after three more seasons, but we can make some conclusions at this point. Particularly, few differences exist among trees on the bulk of the rootstocks involved in this trial. One rootstock, Ishtara, however, attracts interest. It produces a small tree with reduced pruning requirements, and it is productive. Further, when the planting was attacked by peach tree borers a few years ago, Ishtara was resistant. It is interesting to note that Ishtara is the result of a peach x plum cross. All in all, this rootstock is worthy of further trial and possibly limited commercial test planting.

* * * * *

Establishment and Spread of Released *Typhlodromus pyri* Predator Mites in Apple Orchard Blocks of Different Tree Size: 1999 and Final Results

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As discussed by Nyrop in the Winter 1999 issue of *Fruit Notes*, the predatory mite *Typhlodromus pyri* can be highly effective in providing season-long suppression of pest European red mites in commercial apple orchards. Unfortunately, *T. pyri* has been found present (in numbers large enough to be detected) in fewer than 10% of Massachusetts orchards sampled since 1978. In contrast, the predatory mite *Amblyseius fallacis* has been found present in readily detectable numbers in about 90% of Massachusetts apple orchards sampled since 1978. However, *A. fallacis* is less capable than *T. pyri* of enduring cold winter temperatures, withstanding low relative humidities, and surviving periods of short supply of pest mites as food.

In 1997, we initiated a program of introducing *T. pyri* into eight commercial apple orchards in Massachusetts in which it was not previously detected. Two of our aims were to (1) chart the rate at which *T. pyri* spread from trees on which they were released to other trees in the same orchard blocks, as affected by tree size and planting density, and (2) determine the impact of *T. pyri* on pest mite populations. Our study was intended to extend over a period of 3 years. In the Fall 1997 and Winter 1999 issues of *Fruit Notes*, we reported, respectively, on our findings from 1997 (the first year) and 1998 (the second year). Here, we report on our findings from 1999 (the third year) and our final conclusions.

Materials & Methods

As indicated in the Fall 1997 issue of *Fruit Notes*, our experiment was conducted in six blocks of apple trees in each of eight commercial orchards. Of the six blocks per orchard, two each contained trees on M.9, M.26, or M.7 rootstock, designated as small, medium-size, or large trees. One block of each pair received first-level IPM practices, wherein growers applied insecticides and fungicides of their own choosing and timing of application, which extended from April through August. The other block of each pair received third-level IPM practices, wherein the initial intent was that no pesticides known to cause a moderate or high level of harm to *T. pyri* were to be used. These included synthetic pyrethroid insecticides (at any time) and EBDC fungicides (after mid-June). In addition, after mid-June, no insecticide of any type was to be used, and captan or benomyl were the only fungicides to be used. There was no restriction on type of miticide allowable for use in third-level blocks, except for Carzol, which was not used. Each block was comprised of 49 trees (seven rows of seven trees per row) and of the cultivars McIntosh, Empire, or Cortland. Third-level IPM is similar to second-level IPM in its focus on using biologically-based pest-management practices, but it embraces integration with horticultural concerns (such as tree size) as an added component.

T. pyri were released onto the center tree of each third-level IPM block in May of 1997, in the manner described in the Fall 1997 issue of *Fruit Notes*. No *T. pyri* were released in first-level IPM blocks. Three times during the summer of 1997 and four times during the summer of each of 1998 and 1999 in each of the 48 blocks, we sampled 25 leaves from the center tree, 15 leaves from each of the two outer-most trees in the center row, and 15 leaves each from the center tree in each of the two outermost rows. The leaves were sent by overnight mail to Geneva, New York for the identification and counting of pest and predatory mites. In all, more than 12,000 leaves were sampled in 1997 and more than 16,000 in each of 1998 and 1999.

Results

Results on establishment and spread of *T. pyri* for all 3 years (1997, 1998, and 1999) are presented in Figs. 1, 2, and 3. The data show good establishment of *T. pyri* in 1997

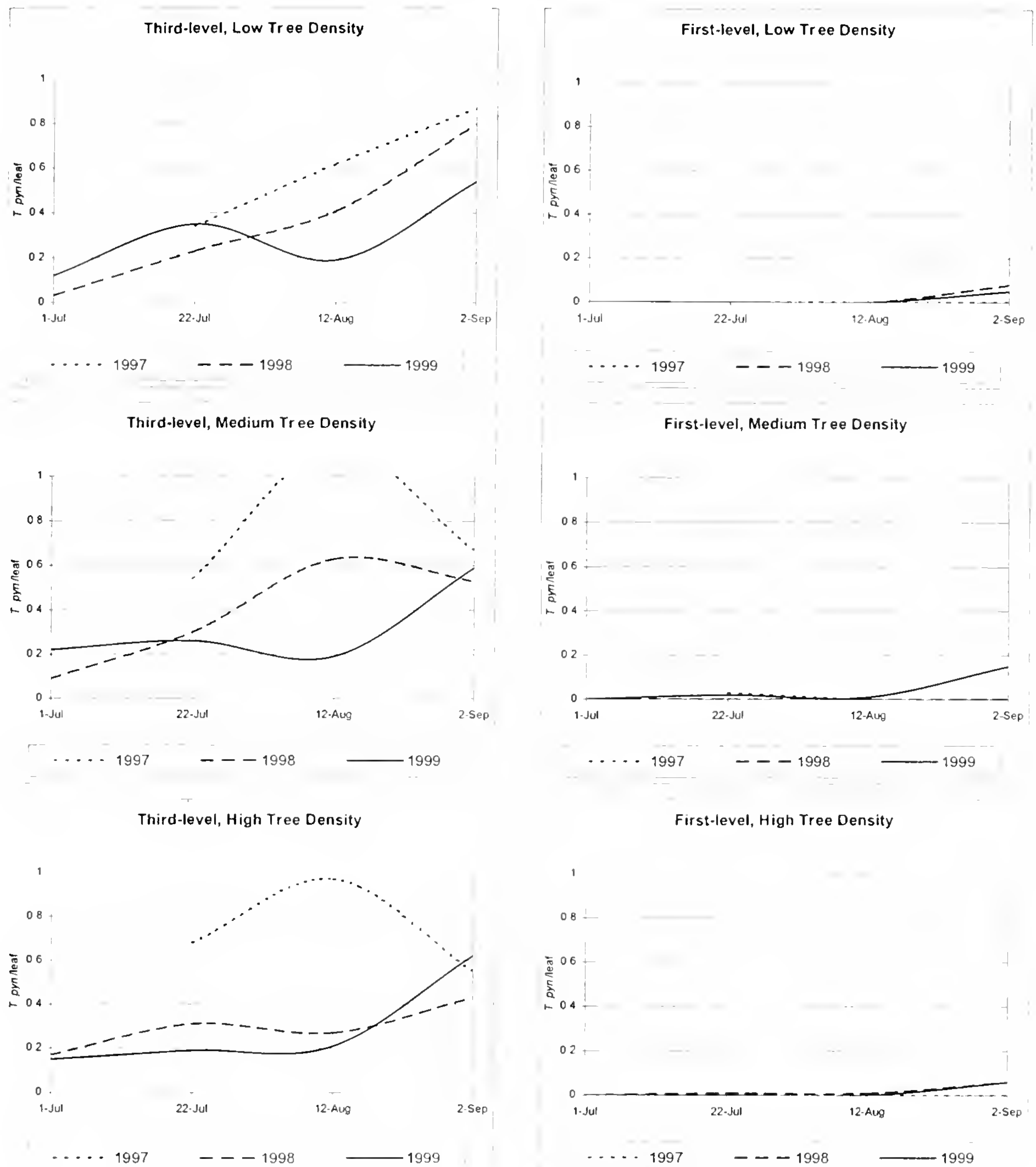

Figure 1. In 1997, 1998, and 1999, abundance to *T. pyri* mite predators on center trees of third-level IPM blocks (in which *T. pyri* were released on center trees in mid-May 1997) and center trees of first-level IPM blocks (in which no releases of *T. pyri* were made).

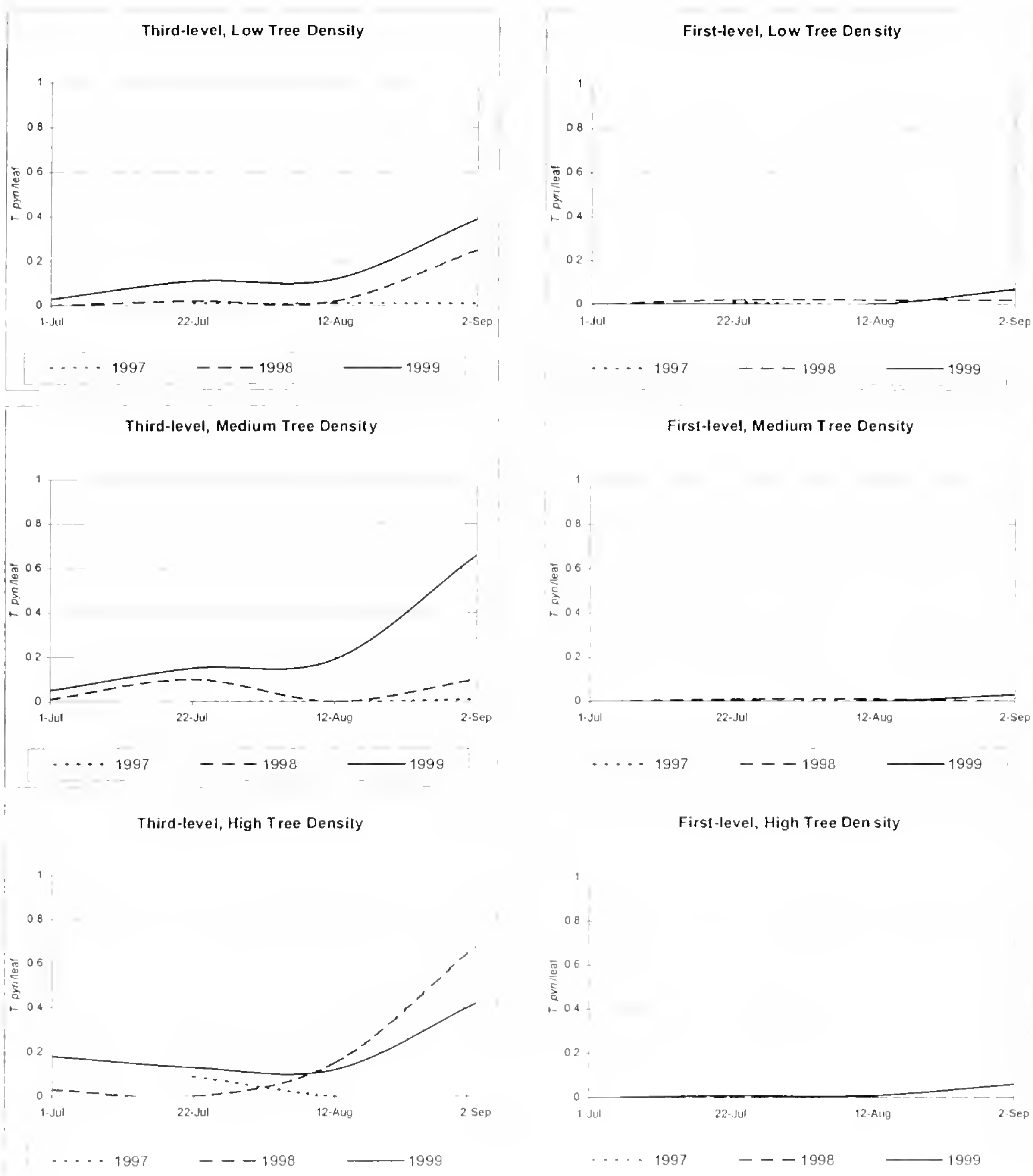

Figure 2. In 1997, 1998, and 1999, abundance to *T. pyri* mite predators on outer trees of center row of third-level IPM blocks (in which *T. pyri* were released on center trees in mid-May 1997) and outer trees of center row of first-level IPM blocks (in which no releases of *T. pyri* were made).

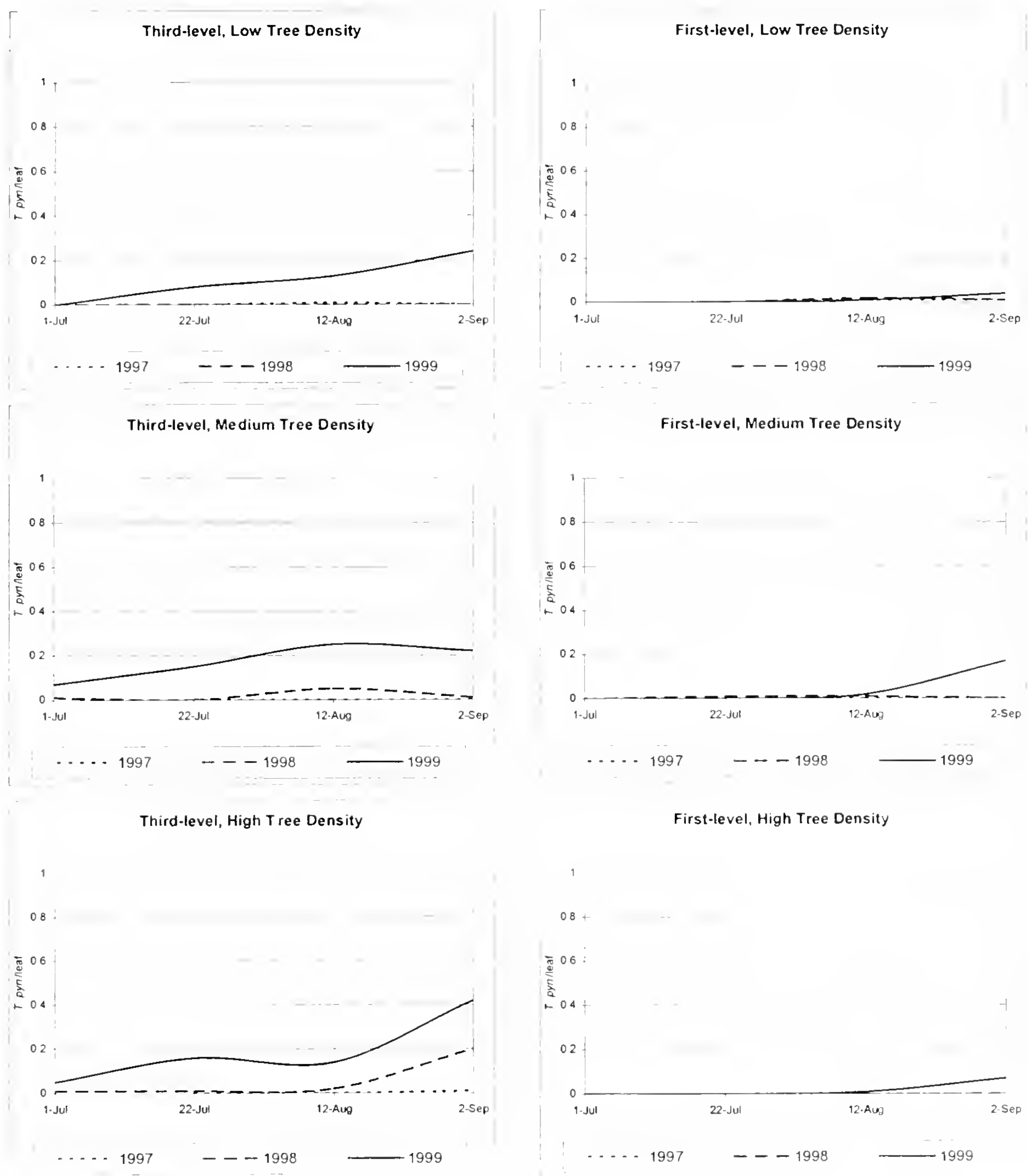

Figure 3. In 1997, 1998, and 1999, abundance to *T. pyri* mite predators on center trees of outer rows of third-level IPM blocks (in which *T. pyri* were released on center trees in mid-May 1997) and center trees of outer rows of first-level IPM blocks (in which no releases of *T. pyri* were made).

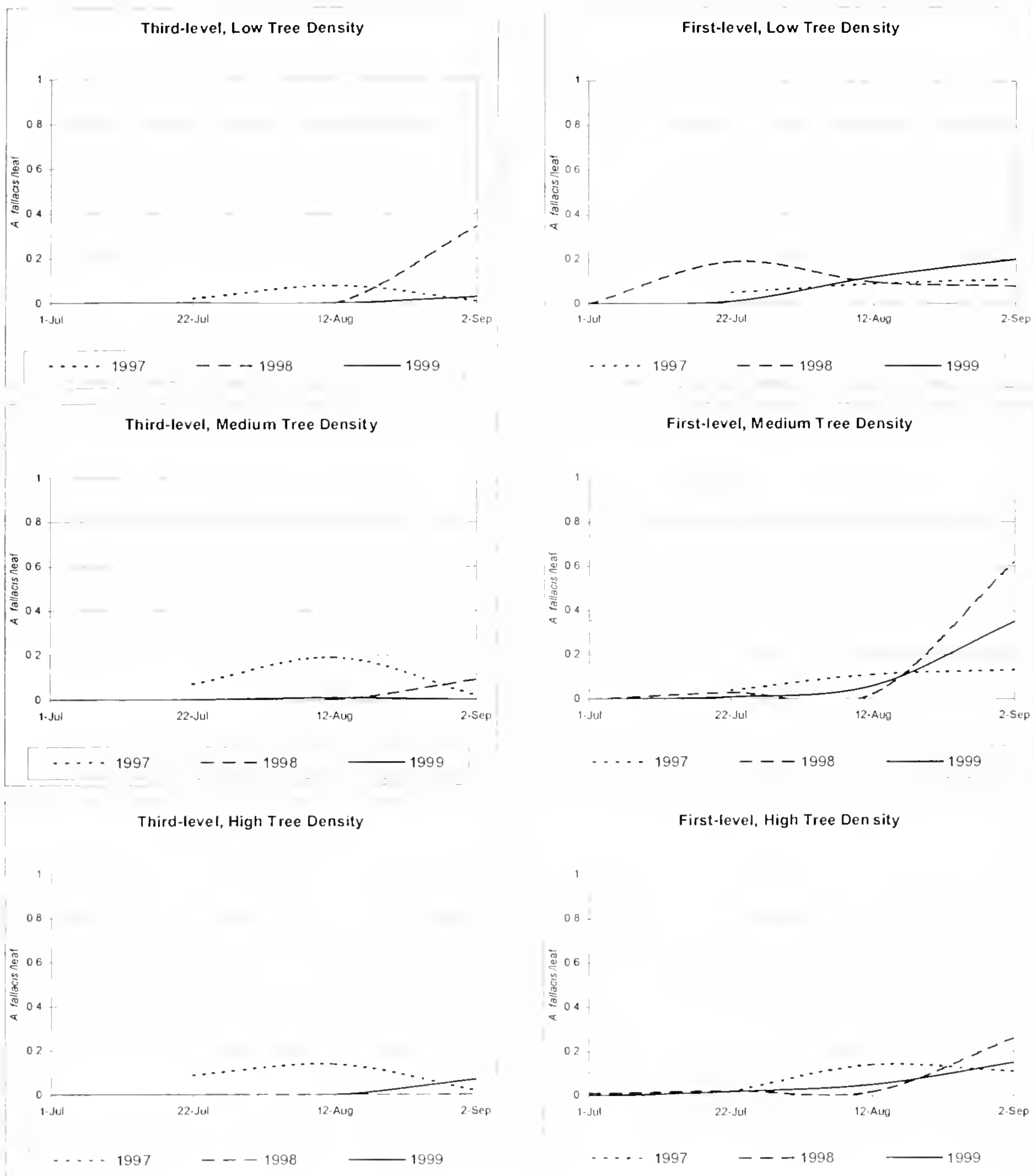

Figure 4. In 1997, 1998, and 1999, abundance to *A. fallacis* mite predators on center trees of third-level IPM blocks (in which *T. pyri* were released on center trees in mid-May 1997) and center trees of first-level IPM blocks (in which no releases of *T. pyri* were made).

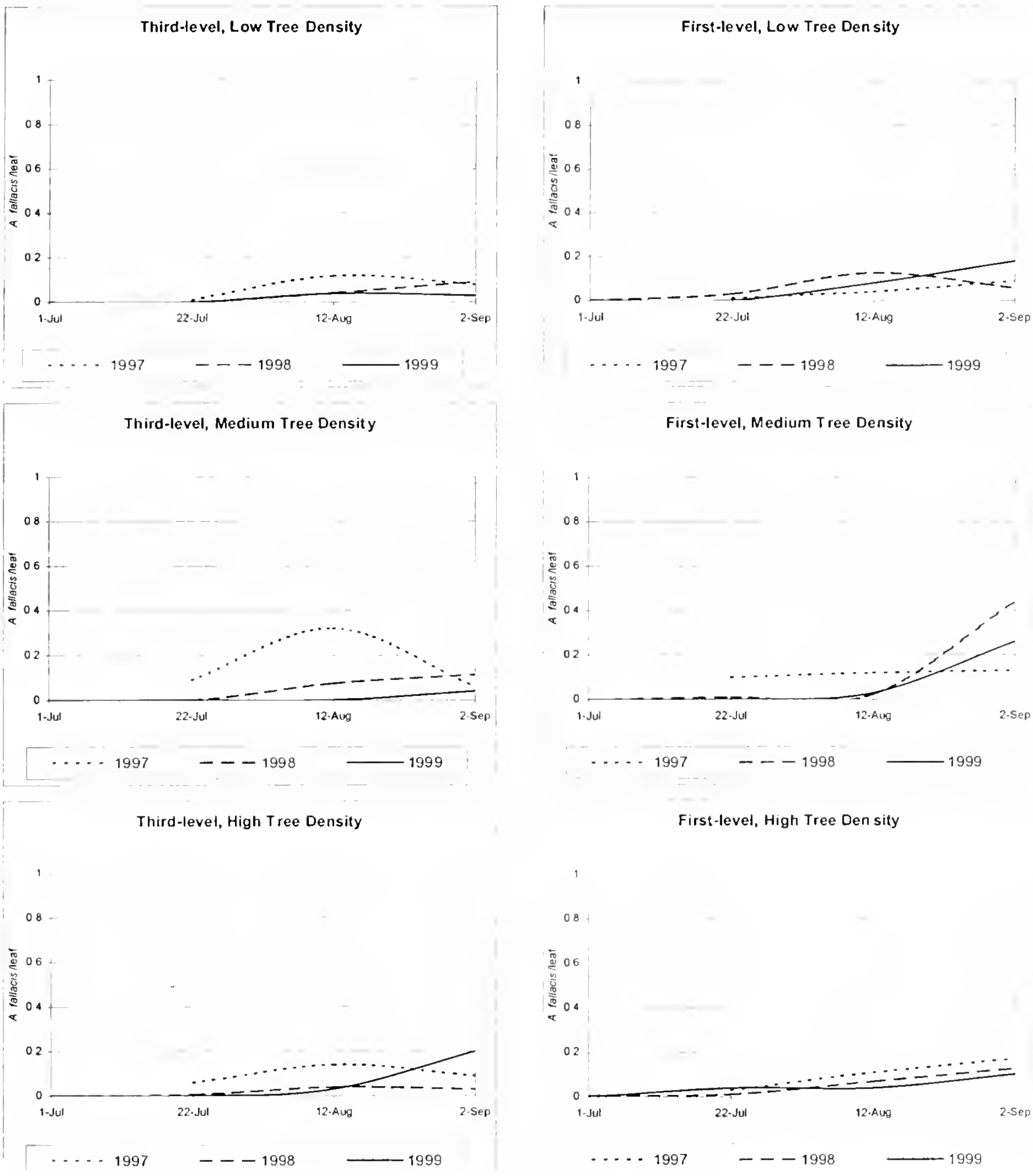

Figure 5. In 1997, 1998, and 1999, abundance to *A. fallacis* mite predators on outer trees of center row of third-level IPM blocks (in which *T. pyri* were released on center trees in mid-May 1997) and outer trees of center row of first-level IPM blocks (in which no releases of *T. pyri* were made).

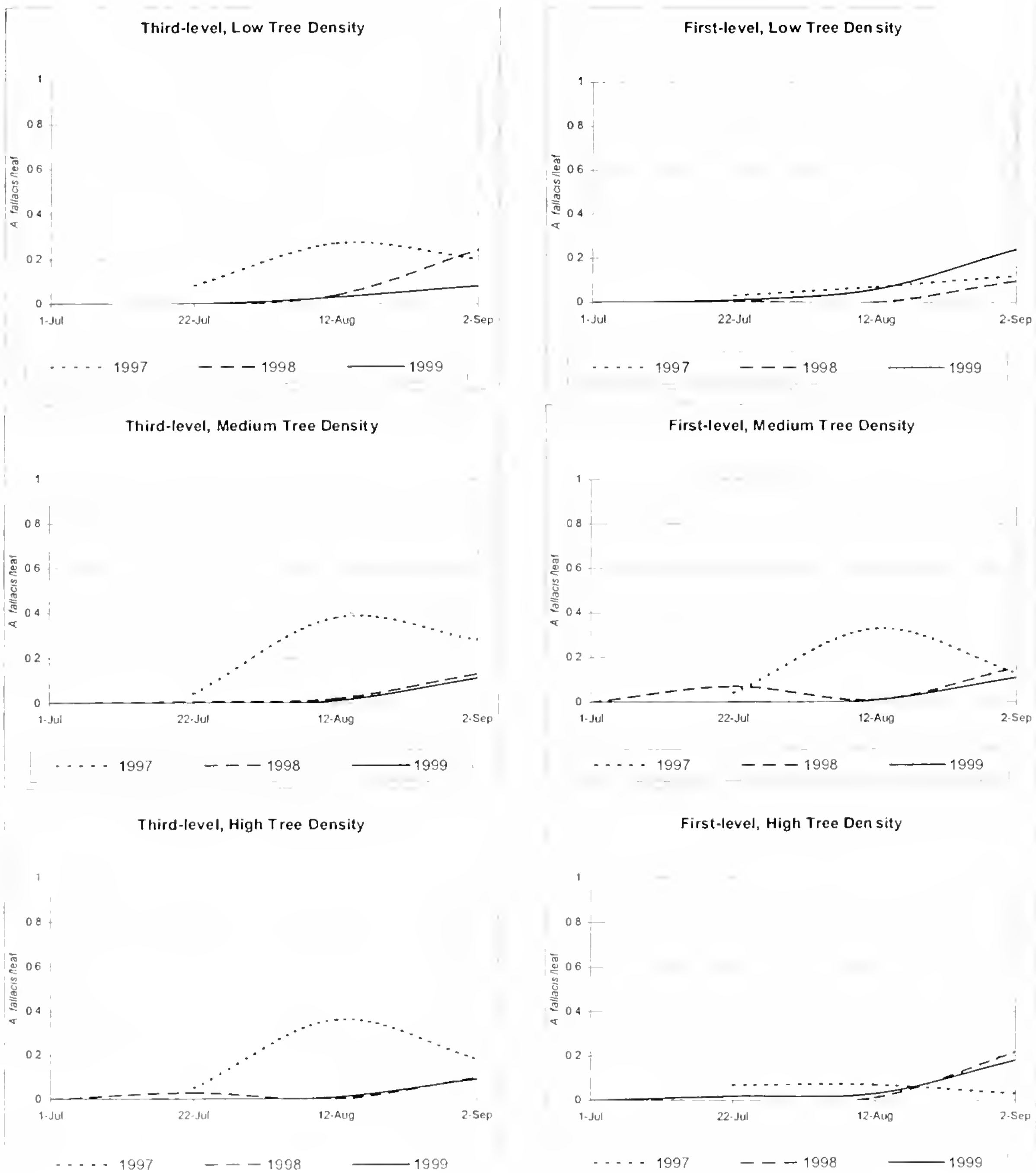

Figure 6. In 1997, 1998, and 1999, abundance to *A. fallacis* mite predators on center trees of outer rows of third-level IPM blocks (in which *T. pyri* were released on center trees in mid-May 1997) and center trees of outer rows of first-level IPM blocks (in which no releases of *T. pyri* were made).

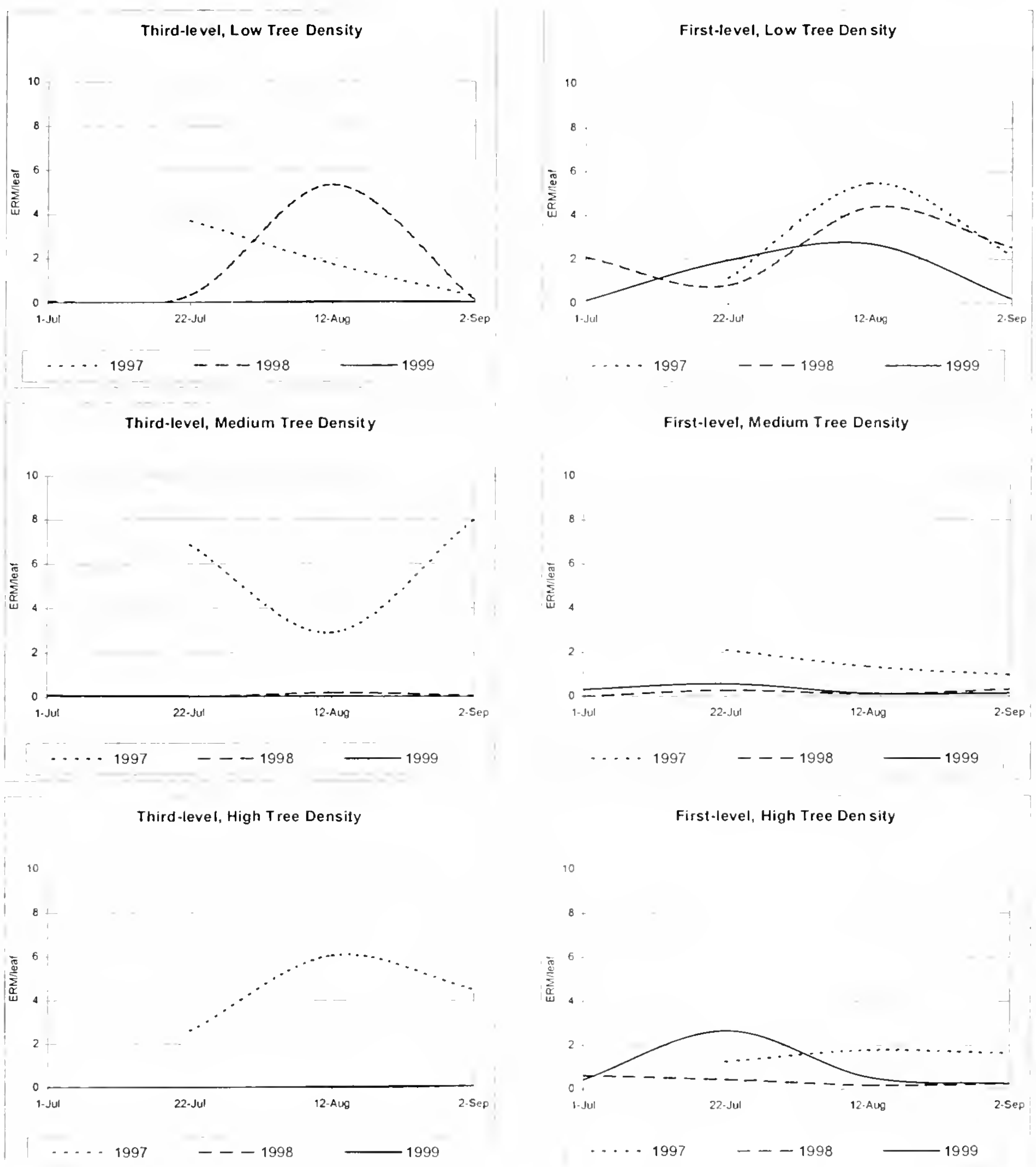

Figure 7. In 1997, 1998, and 1999, abundance to European red mites (ERM) on center trees of third-level IPM blocks (in which *T. pyri* were released on center trees in mid-May 1997) and center trees of first-level IPM blocks (in which no releases of *T. pyri* were made).

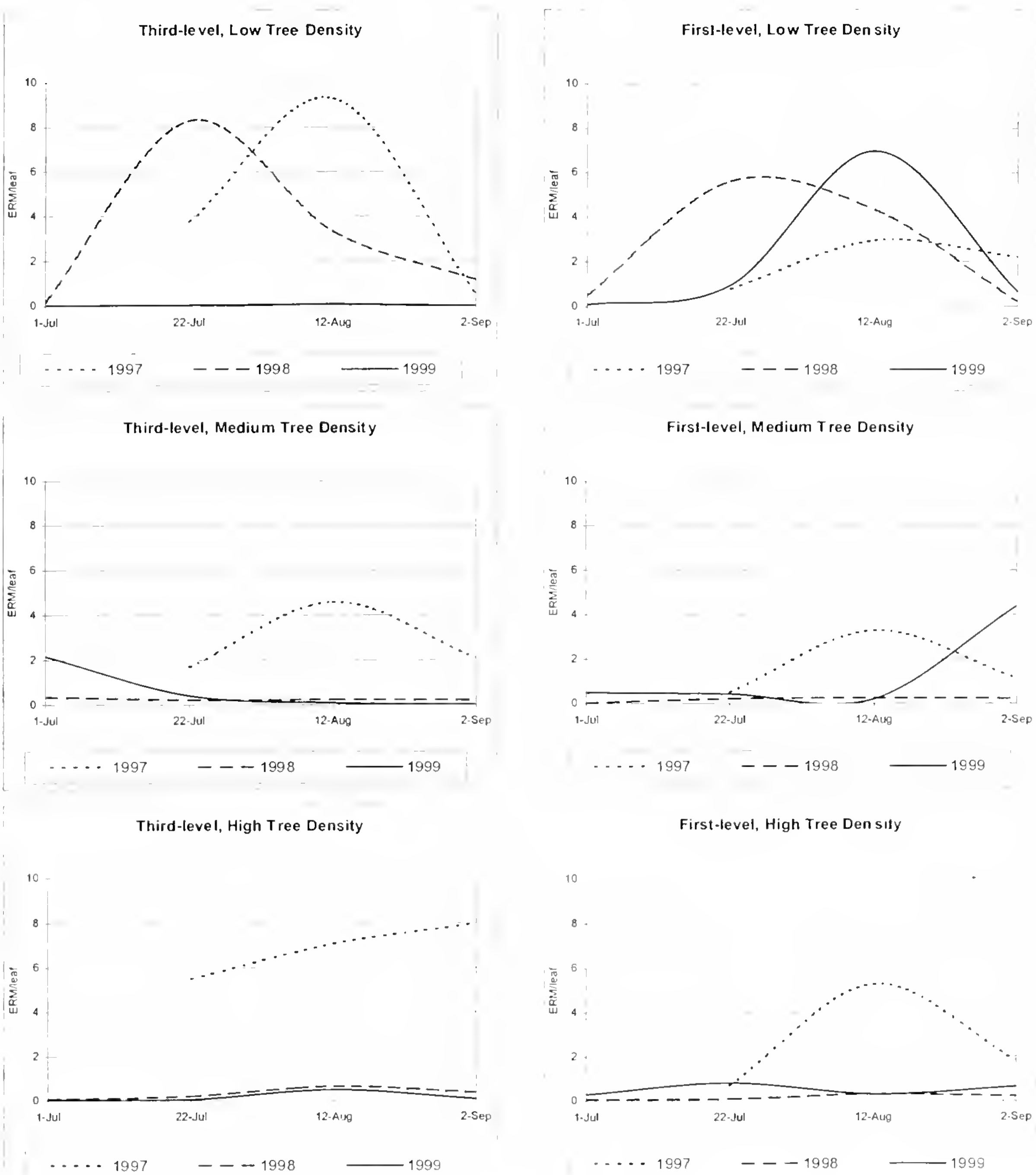

Figure 8. In 1997, 1998, and 1999, abundance to European red mites (ERM) on outer trees of center row of third-level IPM blocks (in which *T. pyri* were released on center trees in mid-May 1997) and outer trees of center row of first-level IPM blocks (in which no releases of *T. pyri* were made).

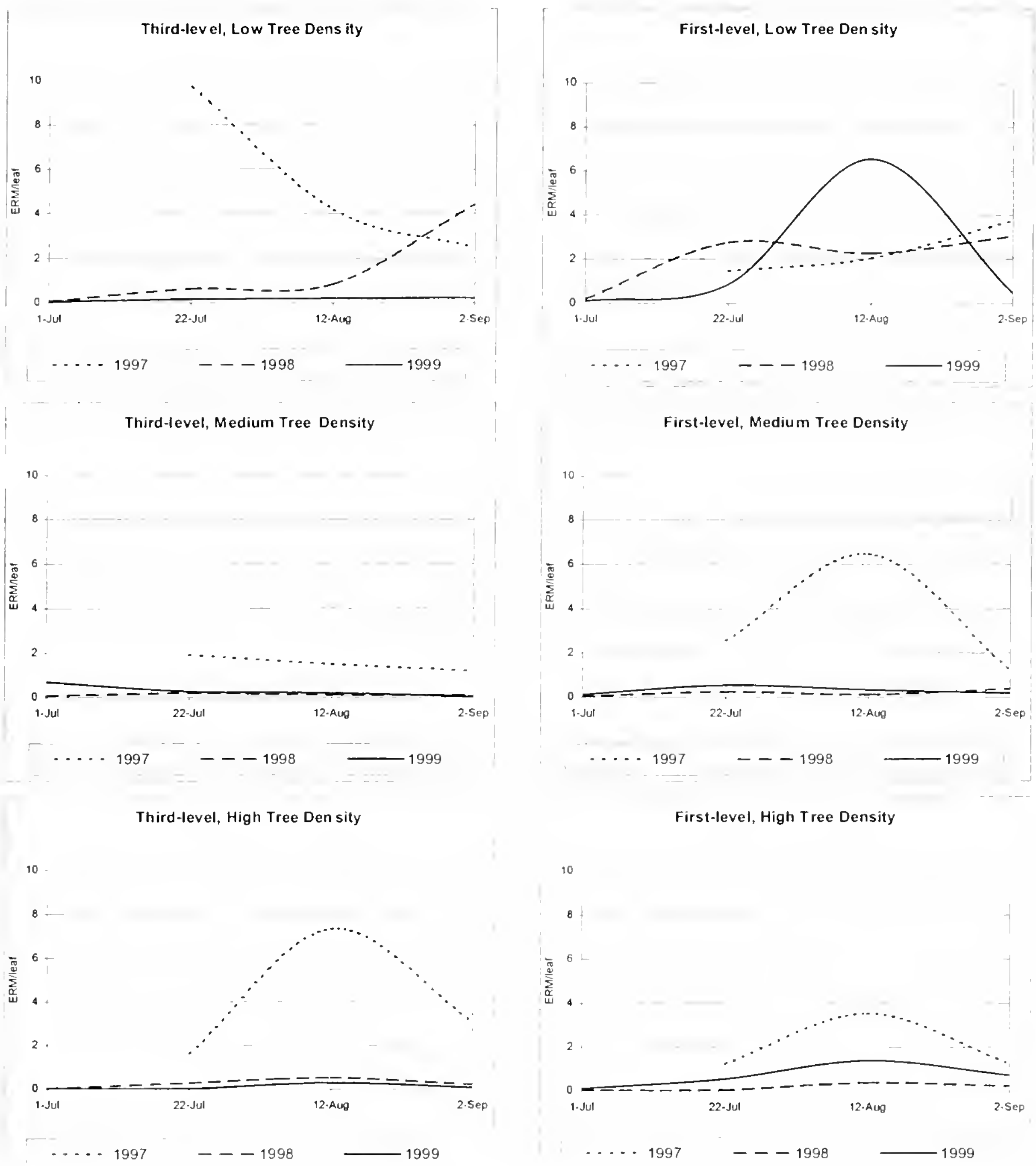

Figure 9. In 1997, 1998, and 1999, abundance to European red mites (ERM) on center trees of outer rows of third-level IPM blocks (in which *T. pyri* were released on center trees in mid-May 1997) and center trees of outer rows of first-level IPM blocks (in which no releases of *T pyri* were made).

on the trees on which they were released, and this establishment was maintained at about the same level during 1998 and 1999 (Fig. 1). Higher numbers of *T. pyri* during 1997 in medium and high-density tree plots were probably due to the higher abundance of European red mite prey. There was very little spread of *T. pyri* in 1997 to the most distant trees up and down the row in which they were released, some up and down row spread (especially in blocks of small trees) by 1998, and excellent up and down row spread in blocks of all tree sizes by 1999 (Fig. 2). There was no detectable spread whatsoever of *T. pyri* in 1997 to the most distant trees across row from which they were released, very slight across-row spread in 1998 (and only in blocks of small trees), and considerable across-row spread in 1999 (especially in blocks of small trees) (Fig. 3). *T. pyri* were essentially absent in 1997 and 1998 from blocks in which they were not released but were detectable in several such blocks (albeit in very low numbers) by 1999, suggesting some spread of *T. pyri* by 1999 beyond the confines of blocks in which they were released (Figs. 1, 2, 3).

Data on presence of *A. fallacis* mite predators (Figs. 4, 5, 6) show a general trend from 1997 to 1998 and 1999 toward lesser abundance in blocks where *T. pyri* were released, compared with blocks where no *T. pyri* were released. There was no apparent influence of tree size or location of sample site within blocks on abundance of *A. fallacis*.

Data on abundance of European red mites (Figs. 7, 8, 9) show little suppressive effect of *T. pyri* in 1997. In 1998, *T. pyri* strongly suppressed European red mites in the small and medium sized trees into which the predators were released. During the same year there was moderate suppression of European red mites throughout the third-level IPM plots of medium and small trees. By 1999 *T. pyri* strongly suppressed European red mites throughout all the third-level IPM plots.

Conclusions

This 3-year study of movement of released *T. pyri* among trees in blocks of different tree sizes (perhaps the only one of its kind) shows that by the third year after release, *T. pyri* can spread effectively as far as three trees away up and down rows and three trees away across rows, with spread fastest and greatest in blocks of small tree size. Also, by the third year after release, *T. pyri* is able to very effectively suppress pest mites in parts of blocks where it has become firmly established. Our findings argue strongly in favor of releasing *T. pyri* for biocontrol of European red mites in apple orchards and suggest that releases be made no further apart than every sixth tree in high-density plantings or every third tree in low-density plantings for rapid establishment throughout an orchard.

Acknowledgments

We are grateful to the eight growers participating in this experiment and who made special effort to apply pesticide selectively to third-level IPM blocks: Bill Broderick, Dave Chandler, Dave Cheney, Dana Clark, Dave Shearer, Joe Sincuk, Tim Smith, and Mo Tougas. This work was supported by State/Federal IPM funds and a grant from the Northeast Sustainable Agricultural Research and Education Program.

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Zestar!™ — a Paulared Alternative for the Northeast?

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Department of Plant & Soil Sciences, University of Massachusetts

Zestar! is a new apple variety introduced in 1999 by the University of Minnesota. It matures with or slightly before Paulared, hence, a comparison of attributes such as fruit quality and taste should be of natural interest to Northeast apple growers. As it turns out, Zestar! may indeed be a good alternative or compliment to Paulared in the Northeast, particularly for roadside markets and farm stands.

University of Minnesota breeders David Bedford and James Luby's narrative of Zestar! includes:

> Description: Zestar! ™ is an early season apple that ripens in late August in east-central Minnesota and is notable for cold hardiness and high fruit quality. It likely will be useful for commercial apple producers and gardeners in the northern U.S., Canada, and other countries with similar climatic characteristics.
>
> Origin: This cultivar was raised as a seedling from the cross State Fair x MN 1691designated as cross AE7214 made in 1972 at the University of Minnesota Horticultural Research Center (HRC) near Excelsior, Minnesota. It was propagated by budding or grafting as MN 1824 for later observations in trial orchards at the HRC, and at the Univ. of Minnesota's West Central and North Central Research and Outreach Centers in Morris and Grand Rapids, respectively.

> Season: Zestar! ™ ripens approximately August 20-26 at Excelsior, MN, approximately one week after State Fair and with Paulared. The fruit adhere well to the tree and can usually be harvested in one or two pickings.
>
> Fruit: The fruit are globose (blocky round) in shape and have an average diameter of approximately 3 inches. The color is 50-85% red stripe depending on exposure to the sun. The stripes may condense into a solid scarlet red in some areas. The flavor is the most notable feature of this variety, being well balanced in acid and sugar content but tasting more sweet than tart. In several years, sensory evaluation panels have rated it as the best or among the best evaluated. The texture is crisp and juicy. The flesh color is white but is prone to oxidative browning when the fruit is cut. The storage life of the fruit in ambient atmosphere at 35°F is approximately 7 weeks, which is better than State Fair or Paulared in our tests.
>
> Tree: The tree form is somewhat upright and vigorous in early years but attains a spur-type habit and moderate vigor as it matures. Trees have exhibited average precocity. Compared to other varieties we have tested, it has average susceptibility to apple scab and moderate susceptibility to fire blight tests. The bloom period is relatively early in the season.

In the short time since its introduction, growers, fruit testers and breeders in the Northeast, Midwest, and Northwest have evaluated Zestar!. Here are some of the comments as published by the Pacific Northwest Fruit Testers Association:

> SW Wisconsin: "It is a very good apple, but of the 30+ trees we planted, all but two have succumbed to fireblight."
>
> Lower Yakima (WA) Valley: "Our two-year-old tress of our commercial planting of Zestar! gave us our first fruit this year. If picked on the early side of maturity, the flavor is lacking, however, if given a little more time the flavor is improved. In general,

Table 1. Fruit quality characteristics of Zestar! and Paulared apples harvested on two dates in 2000 at the UMass HRC.

Characteristic	August 22 Zestar!	August 22 Paulared	August 29 Zestar!	August 29 Paulared
Weight (oz.)	6.2	6.2	6.5	6
Color (% red skin)	48	66	50	74
Flesh firmness (lbs.)	16.1	16.0	14.6	14.6
Soluble solids (% brix)	15.1	12.1	13.8	11.4
Starch index	3.1	3.2	3.9	4.6

the harvest is after Sansa and overlaps Gala. The birds love this variety."

Upper Yakima Valley: "Zestar! picked a bit early on August 7 to accommodate the Tester's Annual Summer Tour did not impress the tour members for lack of flavor, however, that same fruit was put in storage until December 3 and displayed in the Tester's Annual Meeting 'Show & Tell.' Surprisingly, those apple were still firm, crisp, and very flavorful! It appears to have maturity advance in storage."

North-central WA, Wenatchee: "Our first look this year: promising, better than Sansa."

Zestar! has been under evaluation at the University of Massachusetts Horticultural Research Center (HRC) in Belchertown since the first trees were planted in 1996. Overall, we have been impressed with the horticultural characteristics and fruit quality of this variety, particularly at the time of year it ripens and high quality apples are in short supply. Paulared, GingerGold, and Sansa are the only varieties currently recommended that ripen during the pre-Labor Day period that have high quality and are appropriate for both commercial and direct apple markets.

Zestar! trees, as previously described, are distinctly vigorous and upright growing, at least during the establishment years. Once fruiting, it should settle down and produce an easily managed tree. Fruit yields have been light to moderate at the HRC, however, it's large fruit size should help boost overall production. No particular disease or insect problems have been noted, however, it has been reported Zestar is somewhat fire blight susceptible—not a particular problem here in the Northeast..

Zestar! apple's appearance is perhaps one of its weaker characteristics, especially when compared to the more attractive Paulared. Red color of Zestar! has been described as blotchy, and a lighter 'pink' shade of red; whereas, Paulared has a very attractive medium-red blush, freckled with prominent white lenticels.

The flavor of Zestar! is a strong point of this variety. It is judged to be slightly perfumy, aromatic, sprightly, and—true to its name—zesty! Compared to Paulared, the flavor is much more complex, with a good sugar:acid ratio. Paulared flavor is so mild that crispness and juiciness are the dominant characteristics.

In 2000 we compared Zestar! and Paulared fruit harvested on two dates at the HRC to a battery of fruit quality tests and organoleptic and visual evaluations. The results of these evaluations are presented in Tables 1 and 2.

Overall, Zestar! and Paulared were similar in size and flesh firmness. At six plus ounces in weight, both apples are large—about three inches in diameter. Flesh firmness was adequate for an early season apple, and both apples were judged to be crispy on the first harvest date.

But Zestar! and Paulared differed substantially in red skin color and soluble solids (sugar content). Paulared was the clear winner in red skin color, averaging nearly 2/3 and 3/4 of the surface having a red blush on both harvest dates. Zestar! was only about half red, and the color was much 'blotchier', somewhat striped, and more pinkish-red in appearance. Paulared skin color looks like a McIntosh, however, Zestar!'s color is more akin to Honeycrisp or Gala. Zestar! had a much higher sugar content on both harvest dates as indicated by higher soluble solids concentration. Paulared is more McIntosh-like in tartness; whereas, Zestar! has a much sweeter (better acid:sugar balance) flesh.

Based on the organoleptic and visual rating (Table 2),

Table 2. Organoleptic and visual rating (1 <--> 5) of Zestar! and Paulared apples harvested on two dates in 2000 at the UMass HRC.

	August 22		August 29	
Characteristic	Zestar!	Paulared	Zestar!	Paulared
Attractiveness: 1-dislike <–> 5-like very much	3.5	3.5	2.5	4.5
Crispness: 1-not crisp <–> 5-extremely crisp	4	4	3.5	4
Juiciness: 1-dry <–> 5-extremely juicy	3.5	4	3.5	4
Sweetness: 1-not detected <–> 5-very sweet	2.5	1.5	3	2
Acidity: 1-none, bland <–> 5-very tart	3.5	4.5	3	3.5
Flavor: 1-dislike <–> 5-like very much	4.5	3	4.5	3
Desirability: 1-dislike <–> 5-like very much	4	3.5	4	3.5
Color: 1-dull <–> 5-bright	3	3.5	2.5	4
Fruit shape: 1-uniform <–> 5-severely mis-shapen	2.5	1.5	2.5	1.5
Skin: 1-tender <–> 5-tough	1.5	4	2	2.5
Flesh firmness: 1-soft <–> 5-hard	4	4	3.5	3
Astringency: 1-low <–> 5-high	3	3.5	3	3
Flesh color: 1-greenish <–> 5-yellow (3-white)	4	3	3.5	3.5
Cork spot: 1 = 0 <–> 5 = 10+	1	1	1	1
Bitter pit: 1 = 0 <–> 5 = 15+	1	1	1	1
Watercore: 1-none <–> 5-severe	1	1	1	3

neither apple emerged as being clearly superior. Some notable differences between the two apples were observed, however, and they include:

On August 29, Paulared was judged more attractive than Zestar!. The less attractive, blotchy pinkish-red skin color on Zestar! compared to the more extensive red blush of Paulared is the reason.

Zestar! was sweeter than Paulared on both harvest dates. This is to be expected given the higher soluble solids measured in Zestar!.

Zestar! was preferred over Paulared in flavor. Zestar! flavor is complex, with balanced sweetness, tartness, and aromatics that are perfumy and distinctly floral. The muted flavor and elevated levels of acids were less desirable with Paulared.

Paulared had a much higher color rating (brightness) on August 29 compared to Zestar!. Zestar!'s skin color was lacking, particularly on the second harvest date.

Paulared appears to have a more uniform shape (round), vs. the more irregular shape of Zestar!.

The skin of Paulared was much tougher on the first harvest date compared to Zestar!. By the second harvest date they were comparable in skin toughness (or tenderness).

Water core was prevalent in Paulared harvested on August 29, whereas none was observed in Zestar! fruit.

We conclude that both Zestar! and Paulared have a place in New England orchards, especially where sales are direct to the public. Paulared is an early McIntosh-like apple with a red blush over green background and fine white flesh. For individuals who are looking for and early McIntosh-type apple, Paulared is still an excellent choice. Zestar! has an entirely different flavor and appearance, and would likely appeal to people with a different palate. It's excellent and distinctive taste, however, should still please many people.

* * * * *

Growing Winter Raspberries in a Greenhouse

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Navigating snowy, ice-covered roads on the way to market is among the challenges facing a new type of raspberry grower. A few innovative producers are harvesting up to 60 flats (720 half-pints) of fresh raspberries from a 20 X 30 ft. house between February and May, and selling them for \$2,000. Greenhouses have been used for many years to produce tomatoes and cucumbers during winter, but these vegetables require relatively warm temperatures and high levels of light, making their production expensive. Raspberries, however, are uniquely suited for greenhouse production during the off-season. They grow best at cool temperatures (60 - 70°F) and do not require supplemental light to produce a crop, especially if production is targeted for May and June. In northern states, many greenhouses are empty during the winter months, but these could be used to grow raspberries with only moderate inputs, providing greenhouse owners with an opportunity to produce an extremely high value crop during a time of the year when they are realizing no return on their capital investment and when no domestic raspberries are available.

The vast majority of winter raspberries currently on the market are flown in from the Southern Hemisphere. Quality is generally poor, because raspberries have an extremely short post-harvest life and bruise easily during shipping. As a result, consumers are willing to pay between \$3.00 and \$6.00 per half-pint for fresh fruit of superior quality, and restaurant chefs seem willing to pay even more.

Local raspberry production is now possible because of two accomplishments in the area of entomology. First, bumble bees have now been domesticated and are available in small hives for pollinating greenhouse crops. Bumble bees perform better than honey bees in greenhouses, especially under the cooler temperatures used for growing raspberries. Second, predatory mites are now available that feed on phytophagous mites, and these can keep populations of damaging mites at low levels.

Compared to field production, greenhouse-produced berries are larger, firmer, and much less prone to fruit rot. Fruit tends to be slightly less sweet and more acid in the greenhouse, but well within the limits of acceptability. Varieties differ in performance and flavor, and what might do well in the field will not necessarily perform well in the greenhouse. According to our research and work done in Belgium, the variety Tulameen from British Columbia is the best floricane-fruiting raspberry in the greenhouse, although it will not survive most winters outdoors in northern climates. If temperatures drop from above freezing to below 10°F, canes can be damaged.

Production Basics

Tulameen tissue-cultured raspberry plugs are planted into 2-gallon pots filled with equal parts sand, peat, perlite, and vermiculite in May and allowed to grow outdoors on a gravel bed with irrigation. While outdoors, plants are fertilized while irrigating with a complete soluble fertilizer solution containing 100 ppm N, and pest outbreaks are managed using conventional practices. Rows of pots need to spaced about 8 ft. apart so that sufficient light will be intercepted by the lower leaves on the canes. If the plants are too close together, the lower buds will not produce fruiting laterals once they are moved into the greenhouse. In October after leaf drop, pots are moved closer together and bales of straw are placed around the group of pots to help protect them from cold temperatures. Root systems are more sensitive to cold temperatures than canes, so temperatures near zero for an extended period of time will kill roots in pots that are setting on top of the ground. In late December, plants are moved into the greenhouse. (Plants may have to be moved earlier if late December temperatures are forecast to fall below 10F. In this case, move plants into an unheated greenhouse until the end of December.)

Once in a warm greenhouse, canes are spaced pot-to-pot with 5.5 ft. between rows, trellised, and watered with a 100 ppm N complete fertilizer solution. Short or broken canes are removed. Household fans are used to circulate air down the rows to reduce pockets of high humidity (ideal is 65 – 75%) and the subsequent risk of fungal infection. Temperatures are maintained at 65 - 70°F during the day, and 50 - 55°F at night - ideal for raspberries but too cold for most other plants. Supplemental light can accelerate development by 2 to 3 weeks and increase yield by 20 - 30%, but may not be economical, depending on markets.

Six weeks after moving plants into a lighted greenhouse, they flower. Bumblebees are used to pollinate the flowers, and fruiting can begin as early as mid-February, about 10 weeks after moving plants indoors. Once flowering begins, the nutrient solution is reduced to 50 ppm nitrogen. With one-year-old plants, double rows (with row centers 5.5 ft. apart) and a pot-to-pot spacing are used so that approx. 20 plants are contained in each 10 ft. length of row. Each "baby" plant produces about two half-pints of fruit. All but four new canes (primocanes) are removed. These four will bear next year's crop.

After the first harvest is over (in April, May or June), plants are transplanted into 5 or 7 gallon pots (less sand is needed when transplanting into larger pots) with primocanes

intact and placed outside in full sun for the second growing season. Raspberry plants must be supported outdoors to prevent the wind from blowing them over. We use bamboo stakes to hold canes upright in the pots. When primocanes reach 6 ft., they are topped to retard growth. Plants are returned to the greenhouse in mid-December - after the chilling requirement had been fulfilled. Rapidly satisfying the chilling requirement is one advantage that northern growers have over more southern producers. Plants are watered regularly and fertilized once a week with a soluble balanced fertilizer (100 ppm N). In the second production cycle indoors, plants are spaced 22 in. apart in single rows, with 5.5 ft. between rows, and canes are trellised upright to a single wire. In the second and third fruiting years, both fruiting laterals and primocanes will be growing and competing for limited light. In order to regulate self-shading yet have large primocanes for next year's crop, we tip the largest four primocanes per pot at a 3 ft. height; the remaining primocanes are removed at ground level. This allows the fruit to be harvested without significant interference from the primocanes. Primocanes will begin regrowth after several weeks, and will continue growing once they are moved outdoors again. Raspberry plants will fruit for three years before beginning a decline.

If producers do not want to take the time to grow their own plants, full-grown raspberry canes dug directly from the field in early winter can be used to produce fruit that same spring. These plants will be slower to flower and fruit than full-grown potted plants, but are nearly as productive. If using "long-cane" plants, allow them to acclimate in pots in a cold greenhouse for two weeks before warming the house to 65°F.

Twospotted spider mites thrive in the warm, dry conditions of a greenhouse. To reduce the number of mites, we treat canes with horticultural oil within a few days of being moved inside the greenhouse. Since no pesticides have been labeled for greenhouse raspberry production, biological controls must be used for twospotted spider mites after plants are moved inside. Cool temperatures, high humidity, periodic releases of predatory mites, and removal of infested leaves help reduce numbers of pests.

Experiments

We are quantifying growth and canopy development, and responses to light, temperature and carbon dioxide, in an attempt to develop a model the describes and predicts growth and yield under various environmental conditions. This information will be useful for optimizing greenhouse-growing conditions. Cooperators in Minnesota are examining how changing the environmental conditions after flowering might enhance productivity, and cooperators in Alaska are trying to understand the chilling requirement.

We are also studying the effect of initial pot size and transplanting on plant growth. Is it worth transplanting one-year-old plants after the first fruiting cycle to save space, or should they be planted directly into their "adult" containers? If planting directly into containers, what size should they be?

Are "long-cane" plants grown in nurseries in California as good as plants from Washington State? Our trials suggest that California plants are somewhat better.

We have also artificially chilled plants prematurely in coolers in mid-August and mid-September to determine if they would flower earlier than normal. After 8 weeks in coolers, plants chilled in both August and September produced flowers in the greenhouse as early as December. Defoliation of plants prior to chilling had no effect. This finding opens the possibility of significantly lengthening the fruiting season of greenhouse raspberries. Starting production earlier would have several advantages. Raspberry production would be complete before bedding-plant season begins in April, allowing more greenhouse space to be available for use. Also, vents are closed when the outdoor temperatures are cold, allowing the grower to supplement the atmosphere with carbon dioxide, enhancing plant growth. Once temperatures warm in spring, houses have to be vented to cool them and the carbon dioxide escapes. Again, an earlier start would improve efficiency of carbon dioxide use.

Researchers in Ontario are extending the season with primocane-fruiting varieties, moving them inside the greenhouse in early September before the onset of cold weather. These varieties continue to fruit during autumn, and by pruning them, it is possible to obtain continuous fruiting during the winter. However, production then is less than with floricane-fruiting varieties.

Summary

Raspberries are the most perishable of all fruits, so even though they can now be grown close to market, they must still be handled with the utmost of care. Raspberries must be cooled quickly after harvest, and delivered to the customer as soon as possible. Most markets for winter raspberries are small, so a producer will need to line up and supply a larger number of smaller markets than typical.

Despite these challenges, the opportunities for producers are great. At this point, there exist only a few winter raspberry producers , so the market is open. Furthermore, the quality that can be produced is very high. Consumers and restaurant chefs are willing to pay high prices for high quality berries in winter. Further research will lead to an extended harvest season, and eventually, to year round production.

For more information on greenhouse raspberry production, visit the website: http://www.hort.cornell.edu/department/faculty/pritts/greenhouse/Frontpage.htm

* * * * *

Small-plot Trials of Surround™ and Actara™ for Control of Common Insect Pests of Apples

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Given the likelihood of removal or restriction of some current chemical tools for management of key pests of apple in the Northeast, pursuit of improved chemically or biologically based alternatives to standard materials has gained emphasis. In the 2001 growing season, we will begin a project designed to evaluate and improve efficacy of multitactic approaches to management of major arthropod pests. Under this project, our research goals for the 2001-2002 growing seasons rely on the availability of potentially effective new chemicals to substitute for current standards, particularly Guthion and Imidan. Of recently (or soon-to-be) labeled materials, a few may fill potential gaps in arthropod management in the absence or restriction of organophosphate and carbamate insecticides. As a lead-in for the 2001-2002 project phase, we conducted small-plot tests of two new insecticides: Actara (thiamethoxam) and Surround (kaolin clay).

In this study, our objectives were to (a) evaluate two rates of Actara for control of early-season fruit-injuring pests (principally European apple sawfly and plum curculio) and (b) evaluate Surround for control of all insect pests of fruit active after pink (European apple sawfly, plum curculio, apple maggot, leafrollers, codling moth, oriental fruit moth, San Jose scale, and stink bugs).

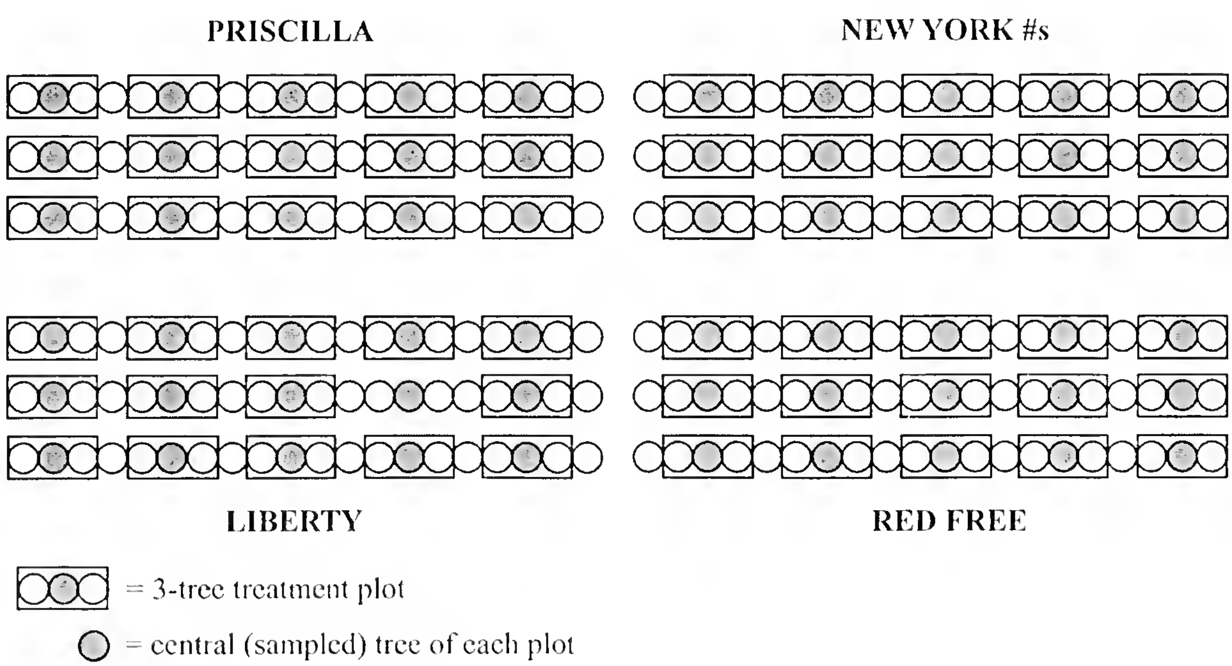

Figure 1. Plot design, University of Massachusetts Horticultural Research Center. Treatments were applied to three-tree plots, with each treatment randomly distributed within a variety/row. Each treatment was replicated 12 times. Fruit samples were drawn from the central tree in each plot.

Materials and Methods

Actara 25WG (25% thiamethoxam). As discussed in the Fall 1999 issue of *Fruit Notes* and the 2000 *March Message*, Actara is a second-generation neonicotinoid compound with a mode of action similar to its cousin, Provado. This material at 4-6 oz. per acre (formulated) is locally systemic and has demonstrated effectiveness against sucking insects (such as leafhoppers, aphids, and pear psylla). Efficacy against tissue-feeding pests (such as leafminer, sawfly, and plum curculio) is under study. As of this writing, Actara has not received a full federal label.

Surround WP Crop Protectant (100% kaolin clay). As reported in the Summer 1999 issue of *Fruit Notes* and the 2000 *March Message*, Surround WP Crop Protectant is a nontoxic, mineral-based, sprayable particle barrier film. A sprayed application of the clay (25-75 lbs. per acre, depending on tree size) physically deters a wide range of pests—at the start of the 2000 growing season, this product was labeled for use against European red mites, rust mites, two-spotted spider mites, codling moth, plum curculio, leafminers, lygus bugs, leafrollers, tarnished plant bug, stink bugs, apple maggot, thrips, green fruitworm, and aphids.

Test Block (Horticultural Research Center, Belchertown). The test block consisted of a 1-acre planting of 240 scab-resistant trees planted in 1988-1990 on M26 rootstock. In this block, four scab-resistant varieties were planted in quadrants, 20 trees long x three rows wide (Figure 1). Each treatment was applied to 3-tree plots (distributed randomly within each row of each quadrant), yielding a total of 12 replicates for each treatment. All treatments (Table 1a) were applied with an airblast sprayer at 100-240 gallons per acre (depending on treatment). All fruit samples were drawn from the center tree of each treatment.

Results

Early-season pests. Beginning at pink bud stage, we evaluated three experimental spray programs (Treatments 2, 3, 4—Table 1b) in comparison with both a label standard

Table 1a. Formulations and rates of tested materials.

Material	Formulation	Rate per 100 gallons	Rate (formulated) per acre
Imidan	70W	.75 lb.	1.8 lb.
Actara Low	25WG	4.5 oz.	4.5 oz.
Actara High	25WG	5.5 oz.	5.5 oz.
Surround	100WP	50 lb.	50 lb.

Table 1b. Chemical treatments and application intervals.

Date	1 Imidan	2 Actara Low	3 Actara High	4 Surround	5 Untreated
May 5 (PK)	Imidan			Surround	
May 15 (PF)	Imidan	Actara	Actara	Surround	
May 25	Imidan	Actara	Actara	Surround	
June 5	Imidan	Actara	Actara	Surround	
June 15	Imidan			Surround	
END OF EARLY-SEASON TREATMENTS					
July 1	Imidan			Surround	
July 15	Imidan			Surround	
August 1	Imidan			Surround	
August 15	Imidan			Surround	

(Treatment 1) and an untreated control (Treatment 5) for management of European apple sawfly and plum curculio. In accordance with label recommendations, we applied four sprays of Imidan (=label standard) at 10-day intervals beginning at pink (May 5), four sprays of Surround at 10-day intervals beginning at pink (May 5), and three sprays of Actara at 10-day intervals beginning at petal fall (May 15). For the duration of the study, the untreated control received no insecticide or fungicide.

Table 2. Mean % fruit damaged by European apple sawfly. Means within a row followed by the same letter are not significantly different at odds of 19:1.

Date	1 Imidan	2 Actara Low	3 Actara High	4 Surround	5 Untreated
June 2*	0.5ab	0.9ab	1.7a	0.0b	0.8ab
June 19*	0.5a	0.0a	1.7a	0.0a	0.9a
Harvest**	0.0b	0.2b	0.4b	0.2b	2.3a

* 20 fruit sampled per replicate (total = 240 fruit per treatment).
** 50 fruit sampled per replicate (total = 600 fruit per treatment).

Table 3. Mean % fruit damaged by plum curculio (oviposition injury). Means within a row followed by the same letter are not significantly different at odds of 19:1.

Date	1 Imidan	2 Actara Low	3 Actara High	4 Surround	5 Untreated
June 2*	0.5b	1.4b	1.7b	1.7b	6.7a
June 19*	12.4b	10.9b	7.8b	9.1b	23.0a
Harvest**	4.2b	9.8b	10.3b	6.3b	20.8a

* 20 fruit sampled per replicate (total = 240 fruit per treatment).
** 50 fruit sampled per replicate (total = 600 fruit per treatment).

To monitor the buildup of early-season pest damage, we sampled 20 fruit from the central tree of each treatment plot (240 fruit per treatment) for damage inflicted by European apple sawfly and plum curculio. Such samples were taken twice during the growing season, in early June and mid June. At harvest, we increased our samples to 50 fruit from the central tree of each treatment (600 fruit per treatment).

For control of European apple sawfly (EAS), we found no significant differences among treatments (including untreated controls) in samples drawn during June (Table 2). These data indicate fairly clearly that pressure from EAS was too light throughout the block to allow judgment of treatment effectiveness with limited fruit samples (mean damage=0.0% to 1.7%). However, more thorough samples taken at harvest yielded a significant difference between all chemically treated plots (mean damage=0.2%) and untreated controls (2.3%). These data suggest that Surround and Actara (at either rate) can offer control of a light EAS population comparable to that of a standard Imidan program.

No treatments provided a commercially acceptable level of plum curculio (PC) control through June, with damage reaching 7.8% to 12.4% in chemically treated plots by June 19 (Table 3). However, for this trial, it is important to bear in mind the likelihood that many PCs found safe harbor in untreated controls (which would not be found in commercial orchards) during June, likely spilling over into treated areas. This may account for the high level of PC injury seen across all chemical treatments. That said, all treatments yielded significant reduction of PC oviposition injury in comparison with untreated controls (23.0% PC injury) through June 19. Further, all chemical treatments provided statistically identical control of PC, again suggesting that Surround and Actara (at either rate) may offer control of PC comparable to Imidan. In samples taken at harvest (reflecting the full effects of June drop and possible late-June buildup of PC injury), all experimental treatments maintained a level of PC control that was statistically equal to treatment with Imidan. However, in late-season samples, it was often difficult to distinguish between distorted PC oviposition scars

Table 4. Mean % fruit damaged by apple maggot fly. Means within a row followed by the same letter are not significantly different at odds of 19:1.

Date	1 Imidan	4 Surround	5 Untreated
July 21*	0.0a	0.0a	0.0a
August 11*	1.2a	0.0a	0.8a
Harvest**	8.3b	1.2b	24.0a

* 20 fruit sampled per replicate (total = 240 fruit per treatment).

** 50 fruit sampled per replicate (total = 600 fruit per treatment).

and hail damage that occurred in June.

Mid- to late-season pests. After June 19, we revised our sampling protocol to focus on one full-season experimental treatment regimen (for Surround) in comparison with both a standard interval-spray program (for Imidan) and a control (untreated). From July 1-August 15, we applied four sprays (at 15-day intervals, Table 1b) of either Imidan or Surround, and compared levels of insect injury in each with an untreated control. To monitor the buildup of all insect pest injury, we sampled 20 fruit from the central tree of each replicate (240 fruit per treatment) and recorded all insect injury. These samples were taken twice during the growing season, in mid-July and mid-August. As with early-season pests, we increased samples at harvest to 50 fruit per replicate (600 fruit per treatment). Although we recorded damage from each pest individually, data here are compiled into five groups: apple maggot, external Lepidoptera (leafrollers and lesser appleworm), internal Lepidoptera (codling moth and oriental fruit moth), San Jose scale, and incidental pests (notably stink bug).

Despite a statewide apple maggot fly (AMF) population that was extremely low, the test block in this study endured substantial pressure from AMF in late August. Even under relatively high pressure, Surround (1.2% AMF injury at harvest) actually outperformed Imidan (8.3% AMF injury at harvest), and both treatments yielded AMF injury levels significantly lower than the untreated control (24.0% injury at harvest, Table 4). These data strongly suggest that Surround holds promise for control of AMF equal to or better than calendar sprays of Imidan, likely owing to the lengthy residual effectiveness of Surround coverage in the absence of substantial rainfall (as characterized the peak of AMF pressure in late August, Figure 2).

For external lepidopteran pests (combined leafroller and lesser appleworm), both Surround and Imidan yielded fruit damage rates (16.7% and 20.5% damage at harvest, respectively) far below damage inflicted in untreated controls (40.5% damage at harvest, Table 5). Although no treatment offered a level of control that is considered commercially acceptable, this is likely again due to pest spill-over from untreated trees (as seen with PC). As was the case with control of apple maggot, Surround actually provided control of LR and LAW that was numerically superior to calendar sprays of Imidan.

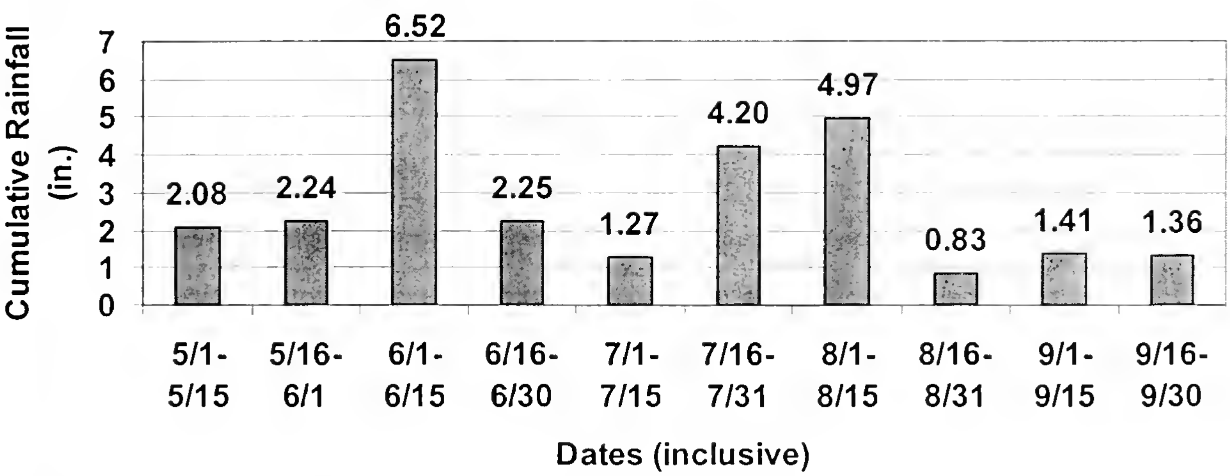

Figure 2. Cumulative rainfall for each 15-day period from May 1 through September 30. Imidan and Surround were applied on May 5, 15, 25, June 5, 15, July 1, 13, August 3, and 16. Actara was applied on May 15, 25, and June 5.

For control of internal Lepidoptera (combined codling moth and oriental fruit moth), samples at each interval revealed a consistent pattern. Both Surround and Imidan (1.5% and 0.5% damage at harvest, respectively) provided significantly reduced levels of damage in comparison with untreated controls (5.2% damage at harvest, Table 6). For this pair of pests, Imidan sprays yielded slightly better control, particularly in early August (the period of greatest rainfall, Figure 2), when a significant amount of Surround coverage may have washed off. Even so, levels of control of CM and OFM through harvest were comparable between Imidan and Surround.

San Jose scale (SJS) has been identified (by other researchers) as a pest for which Surround may not offer optimal control, likely as a result of the seamless coverage needed (with any chemical) for consistent control that is difficult to achieve with this material. In this trial (Table 7), control provided by treatment with Surround (0.5% SJS damage at harvest) was nearly equal to that offered by Imidan (0.2% SJS damage at harvest), and both far outperformed the untreated control (4.0% SJS damage at harvest). However, it is likely that the overall population of SJS was limited within the block (given only 4.0% SJS damage to untreated fruit at harvest), and we can only conclude that Surround offered acceptable control of SJS under limited pressure.

Although our sampling protocol focused on pests that are consistently targets of insecticide sprays in the Northeast, we also sampled for damage inflicted by pests that are

Table 5. Mean % fruit damaged by leafroller and lesser appleworm (combined damage). Means within a row followed by the same letter are not significantly different at odds of 19:1.

Date	1 Imidan	4 Surround	5 Untreated
July 21*	0.0b	1.3ab	4.2a
August 11*	0.8b	2.1b	5.8a
Harvest**	20.5b	16.7b	40.5a

* 20 fruit sampled per replicate (total = 240 fruit per treatment).
** 50 fruit sampled per replicate (total = 600 fruit per treatment).

Table 6. Mean % fruit damaged by codling moth and oriental fruit moth (combined damage). Means within a row followed by the same letter are not significantly different at odds of 19:1

Date	1 Imidan	4 Surround	5 Untreated
July 21*	0.0b	0.4b	3.3a
August 11*	0.0b	1.3ab	2.5a
Harvest**	0.5b	1.5b	5.2a

* 20 fruit sampled per replicate (total = 240 fruit per treatment).
** 50 fruit sampled per replicate (total = 600 fruit per treatment).

Table 7. Mean % fruit damaged by San Jose scale. Means within a row followed by the same letter are not significantly different at odds of 19:1.

Date	1 Imidan	4 Surround	5 Untreated
July 21*	0.0a	0.0a	0.0a
August 11*	0.0a	0.0a	0.0a
Harvest**	0.2b	0.5b	4.0a

* 20 fruit sampled per replicate (total = 240 fruit per treatment).
** 50 fruit sampled per replicate (total = 600 fruit per treatment).

Table 8. Mean % fruit damaged by stink bugs. Means within a row followed by the same letter are not significantly different at odds of 19:1.

Date	1 Imidan	4 Surround	5 Untreated
July 21*	0.0a	0.0a	0.0a
August 11*	0.8b	0.8b	3.3a
Harvest**	0.0b	0.2b	1.8a

* 20 fruit sampled per replicate (total = 240 fruit per treatment).
** 50 fruit sampled per replicate (total = 600 fruit per treatment).

not generally targeted, but may flare up in the absence of organophosphate sprays. These were grouped as incidental pests, and damage within this group was dominated by stink bugs. The pattern of control of these pests (Table 8) was very similar to the pattern of internal Lepidoptera. In each sampling interval, treatment with either Surround or Imidan (0.8% and 0.8% damage at harvest, respectively) significantly reduced damage by incidental pests such as stink bugs in comparison with untreated control (1.8% damage at harvest). As with internal Lepidoptera, the bulk of injury was observed to occur in early August. All told, control of these incidental pests by Surround was consistently comparable to control provided by Imidan.

Conclusions

Data from this study strongly confirm the potential effectiveness of alternative chemicals to replace Imidan or Guthion for control of common apple insect pests. We are particularly encouraged by the fact that Actara provided control of both European apple sawfly and plum curculio nearly equal to control provided by calendar sprays of Imidan. Somewhat discouraging, though, are recent developments surrounding labeling of Actara. It has not yet received a federal label for use in the 2001 growing season and will not include apple maggot (not studied here) in its near-term use recommendations. Even so, when labeled, this material may offer a reasonable alternative to Imidan or Guthion for control of early-season pests, particularly PC.

There is no question from this and other studies that Surround can provide very good season-long control of many (if not all) common insect pests of apple fruit in the Northeast. However, we find several weaknesses in large-scale, season-long use of this material: (1) difficulty of handling and distributing each application effectively (at 25-75 lbs. per acre); (2) risk of wash-off of effective residue by rainfall, which dictates nine treatments per season; (3) need to keep rapidly expanding fruit and foliage completely and uniformly covered throughout the growing season; (4) cost of a season-long Surround program ($225-$675 per acre, depending on tree size and treatment interval); and (5) the challenge of thoroughly rinsing clay residue after harvest. In addition, there are a few negative pest management impacts that have not been fully studied, such as suppression of beneficials (particularly predaceous mites and leafminer parasitoids) and the potential for rapid buildup of secondary pests that can quickly proliferate if spray coverage is not ideal (such as is suspected for San Jose scale). We believe that Surround may still hold potential as an insect management tool in small-scale, limited-spray programs, though application of this material at any scale is challenging, particularly with a backpack sprayer (as in *Fruit Notes*, Summer 1999).

Given slow progress toward labeling (and reported ineffectiveness against AMF) of Actara, along with the handling problems and potential expense of Surround, we will not pursue large-scale testing of either material of the 2001-2002 growing season.

Acknowledgments

We would like to thank the Horticultural Research Center in Belchertown for hosting this trial, along with Joe Sincuk and Alex Clark for applying the experimental treatments. Funding for this project was provided by the manufacturers of the tested materials, Syngenta (Actara) and Engelhard (Surround). Additional project funding was provided by state and federal IPM funds and a grant from the Massachusetts Society for Promoting Agriculture.

* * * * *

Can Surround™ Be Applied Successfully with a Back-pack Sprayer to Control Plum Curculio?

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Tuckaway Farm, Conway, Massachusetts

In the preceding article, information was presented on the effectiveness of kaolin clay (Surround™) in controlling plum curculio (PC) when applied by a mist blower to apple trees on M.26 rootstock at the Horticultural Research Center. Good though not excellent control was obtained using four applications 10 days apart. In the summer 1999 issue of *Fruit Notes*, we reported results of a 1999 trial in which Surround was applied twice against PC to M.26 trees using a Solo™ motorized back-pack sprayer. That study occurred in my small orchard of scab-resistant cultivars in Conway. Again, control of PC was good though not excellent.

Here, I report results of a 2000 trial evaluating effectiveness of Surround applied against PC in my orchard using the Solo sprayer.

Materials & Methods

The trial was carried out using six rows of Liberty apple trees, each with five trees per row. Every other row was sprayed three times with Surround: May 16 (petal fall), May 25 and June 6. Surround was applied at the recommended rate of 50 pounds per acre. Remaining rows were sprayed on these same dates with phosmet at 3 pounds of 70 WP per acre. After June 6, no insecticides were applied to any trees in the orchard. Four apple trees about 200 yards away did not receive any insecticide and served as indicators of PC pressure in the area. At harvest, one-sixth of the fruit (approximately 70 fruit) on each tree were sampled for PC egglaying scars.

Results

Results (Table 1) show that three sprays of Surround were much less effective than three sprays of phosmet in controlling PC in my orchard. Untreated trees about 200 yards away received a large amount of PC injury, but these trees were of different (unknown) cultivars than the Liberty trees in the orchard. Approximately 12 inches of rain fell between May 15 and June 30 (the approximate end of the PC season), which might have compromised the residual effectiveness of Surround to a greater extent than that of phosmet.

Remarks & Conclusion

I experienced little difficulty in mixing the 2000 version of Surround WP in a small amount of water and introducing the mixture as a slurry into the 3-gallon tank of the sprayer. Maintaining adequate mixing of Surround with water did require me to jounce the sprayer frequently, however. This was not kind to my back. To attain the very thorough coverage needed for Surround to be effective in controlling PC on trees 10 feet tall required 0.6 gallons of mixture per tree per application. Effective application of phosmet required only 0.25 gallons of mixture per tree, less than half as much. This resulted in more frequent filling of

Table 1. Percent apples infested by plum curculio adults in commercial orchard trees receiving three applications of Surround or phosmet, Conway, MA, 2000.

Treatment	Number of trees	Injured apples (%)
Surround	14	15.5
Phosmet	15	2.3
Untreated*	4	91.0

*Data from sampled fruit of unsprayed trees of unknown cultivar about 200 yards from the orchard trees.

the spray tank when using Surround.

The greatest challenge of attaining effective PC control with Surround using a motorized back-pack sprayer lies in keeping the new growth of apples and foliage covered with Surround. Unlike phosmet, Surround is not toxic to PC or any other insect. Its mode of action is one of repellency. If a PC or other insect finds a treated surface unacceptable, it can crawl or fly to an untreated or incompletely treated surface and cause damage.

In my judgement, the main reason why Surround performed much better in relation to phosmet in the trial using a tractor-driven mist blower (as reported in the preceding article) than in the trial reported here was the more thorough coverage obtained using the mist blower. Coverage was especially important in 2000, a year in which PC pressured orchards to a much greater extent than in 1999.

My conclusion, based on 2 years of experimentation with Surround vs. phosmet in my orchard, is that phosmet achieves considerably better control of PC than does Surround when application is by a motorized back-pack sprayer and that it does so with much less labor associated with application and with much less cost of material. Despite its shortcomings when applied by a back-pack sprayer, Surround nevertheless does offer the potential for better control of PC on backyard apple trees than does any other non-toxic material investigated to date.

* * * * *

Evaluation of Host-odor Compounds for Attractiveness to Plum Curculio Adults: 2000 Results

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As reported in the summer 1999 issue of *Fruit Notes*, 56 compounds have thus far been identified as components of odor of plum or apple fruit at its most attractive stage to plum curculio (PC). Results presented in that report showed that of 30 such compounds evaluated, 13 proved attractive to PC at either a high, medium or low release rate of compound.

Here, we describe results of 2000 tests in which these 13 compounds (plus four others from 1999) were re-evaluated for attractiveness to PC along with 11 other host-odor compounds evaluated for the first time.

Materials & Methods

Each compound was introduced into a high-density polyethylene vial (VWR Chemical Incorporated) and assessed at three different release rates so as to create a very low, low, or moderate amount of odor concentration in the surrounding air. Desired release rates were achieved by varying the number of vials used per trap and were approximately 0.4, 2.0, and 10.0 milligrams of odor per day.

Compounds were evaluated in association with yellow-green boll weevil traps placed on the ground at the edge of unsprayed apple tree canopies in Massachusetts and Ohio. PCs frequently drop from host tree canopies to the ground and may encounter odor from a nearby baited trap. Each trap was baited with a single compound at a single

Table 1. Response index (RI) of plum curculio adults to 22 host fruit odor compounds evaluated in both Ohio and Massachusetts in 2000 at three different release rates. For each compound, only that release rate which yielded the highest RI value of all is given.

Compound	Release rate	RI	(1999 RI value)**
Benzaldehyde	M	45*	(L 46)*
Benzothiozole	L	20	(H 27)
Benzyl Alcohol	M	27	(L 44)*
Decanal	L	11	(L 64)*
Ethyl isovalerate	M	38*	(M 40)*
Geranyl propionate	VL	33*	(M 59)*
2-hexanol	VL	14	(H 32)*
E-2-hexenal	VL	29	(M 90)*
hexyl acetate	M	50*	(H 67)*
Z-3-hexenyl acetate	M	50*	---
Z-3-hexen-1-ol	VL	0	---
3-hydroxy-2-butanone	VL	25	(H 27)
Isopropyl acetate	L	33*	(L 20)
R(+) Limonene	L	20	(M 64)*
S(-) Limonene	VL	65*	---
Nonanal	VL	33*	(M 0)
1-pentanol	L	71*	(M 59)*
2-pentanol	M	11	(H 35)*
3-penten-2-ol	L	45*	---
Phenylacetaldehyde	L	64*	(H 32)*
Plum essence***	L	0	---
2-propanol	L	33*	(M 32)*

*RI values of 32 or greater can be considered significantly different from zero at odds of 9:1.
**Release rate giving highest RI value in 1999 tests.
***Synthetic version of plum odor made by Milne, Inc.

Table 2. Response index (RI) of plum curculio adults to six host fruit odor compounds evaluated in Massachusetts in 2000 at three different release rates. For each compound, only that release rate which yielded the highest RI value of all is given.

Compound	Release rate	RI
Beta-caryophyllene	VL	0
Cubebene	VL	33*
2,4-decadienal	M	0
Alpha-farnesene	M	0
Ocimene	VL	56*
3-penten-2-one	M	14

*RI value of 32 or greater can be considered as significantly different from zero at odds of 9:1.

release rate or was unbaited. Vials were placed inside the cylinder component of the screen funnel top of the trap. Over a 7-week period from early May to late June, 264 traps were deployed in Massachusetts and another 264 in Ohio for re-evaluation of 17 compounds tested in 1999 plus five other compounds that were comparatively inexpensive to purchase from a commercial supplier (Table 1). In addition, six compounds that were much too expensive to evaluate in both states were evaluated only in Massachusetts (Table 2). Traps were examined for captured PCs every 2-3 days and rotated in position after each examination.

To measure attractiveness of a particular release rate of a particular compound, a Response Index (RI) was created by subtracting the total number of PCs responding to an unbaited control trap (C) from the total number responding to its corresponding baited trap (BT), dividing by the total number of PCs captured by the C and BT traps and multiplying by 100. Thus, RI = [(BT-C)/BT+C)] x 100. The greater the RI, the more attractive the compound was at that release rate. RI values of 32, 50 and 60 correspond to PC captures by baited traps as being two, three and four times greater, respectively, than captures by control traps.

Results

Of the 22 compounds evaluated in both Massachusetts and Ohio (Table 1), 12 had a RI value of 32 or greater (= minimum RI value suggestive of significant attractiveness) at the most attractive release rate. In descending order of attractiveness, these were 1-pentanol (71), S (-) limonene (65), phenylacetaldehyde (64), hexyl acetate (50), Z-3-hexenyl acetate (50), benzaldehyde (45), 3-penten-2-ol (45), ethyl isovalerate (38), geranyl propionate (33), isopropyl acetate (33), nonenal (33) and 2-propanol (33).

Also given in Table 1 are highest RI values from 1999 tests involving 17 of the 22 compounds. Together, data from 1999 and 2000 tests show that seven of the 17 compounds tested in both years had RI values each year of 32 or greater at the most attractive release rate. In descending order of attractiveness (where RI values were averaged across both years even though corresponding release rates may have been different), these seven compounds were: 1-pentanol (65), hexyl acetate (59), phenylacetaldehyde (48), benzaldehyde (46), geranyl propionate(46), ethyl isovalerate (39), and 2- propanol (33). In addition, the average RI value for R(+) limonene in 1999 and S(-) limonene (which contains 25% R(+) limonene) in 2000 was 65.

Results for the six expensive compounds evaluated only in Massachusetts (Table 2) show that only two had RI values of 32 or greater at the most attractive release rate: ocimene (56) and cubebene (33). Ocimene is a biochemical byproduct of limonene.

Conclusions

Results from 2000 tests in conjunction with those from 1999 tests suggest that 10 compounds are especially worthy of further consideration as affordable odor attractants for PC. In alphabetical order these are: benzaldehyde, ethyl isovalerate, geranyl propionate, hexyl acetate, Z-3-hexenyl acetate, limonene, 1-pentanol, phenylacetaldehyde, 3-penten-2-ol, and 2-propanol.

As reported elsewhere in this issue of *Fruit Notes*, benzaldehyde and ethyl isovalerate proved attractive to PCs when each was in combination with synthetic pheromone in traps intended to capture PCs immigrating into orchards as well as in traps intended to capture PCs beneath or within apple tree canopies. Limonene in combination with pheromone also showed evidence of attractiveness to PCs under the latter condition. Each of the 10 most promising host odor compounds reported here merits evaluation in combination with pheromone for attractiveness to PC.

Acknowledgements

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Evaluation of Baited and Unbaited Traps for Monitoring Plum Curculios in Commercial Apple Orchards

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In the summer 1999 issue of *Fruit Notes* we reported in 1999 tests in which we compared odor-baited with unbaited traps for monitoring plum curculios (PCs) in commercial and unsprayed orchards. The odor used was a combination of two synthetic components of host fruit odor (ethyl isovalerate and limonene) plus synthetic male-produced sex pheromone (grandisoic acid). Odor-baited and unbaited traps were of three types: pyramid, cylinder and Circle. Unfortunately, none of these trap types captured significantly more PCs when baited than when unbaited.

Here, we evaluated each of six synthetic components of host fruit odor in combination with grandisoic acid and in association with pyramid, cylinder and Circle traps in 12 commercial apple orchards in 2000. The orchards were those selected for a study of the influence of orchard and border area architecture on third-level IPM practices.

Materials & Methods

The three types of traps were: (a) black pyramid traps (24 inches wide at base x 48 inches tall) placed on the ground next to apple tree trunks, (b) black cylinder traps (3 inches diameter x 12 inches tall) fixed vertically onto horizontal branches within apple tree canopies, and (c) aluminum-screen "Circle" traps (developed by a grower named Edmund Circle in Oklahoma for pecan weevils) wrapped tightly around ascending tree limbs and designed to intercept PC adults walking upward.

The six synthetic components of host fruit odor were among the most attractive of the 30 components evaluated in 1999 in conjunction with boll weevil traps placed on the ground (results reported in the summer 1999 issue of *Fruit Notes*). They were benzaldehyde, decanal, ethyl isovolerate, hexyl acetate, limonene, and trans-2-hexenal. Each was purchased from Aldrich Chemical Company and was deployed in small polyethylene vials that fit into the screen-funnel top of a boll weevil trap that capped each pyramid, cylinder or Circle trap. The release rate of each compound was about 10 milligrams per day (achieved by adjusting the number of vials per trap according to compound volatility). Each baited trap also contained a plastic dispenser of grandisoic acid (obtained from Chem-Tica, Inc. in Costa Rica) designed to release about 5 milligrams of pheromone per day.

Traps were placed in plots of four apple trees in each of the 12 orchards. Each plot consisted of seven perimeter trees. Each tree (save one) contained one baited or one unbaited trap of the above three types. All three baited traps in a given plot received the same odor. In each orchard, each of three plots received a synthetic fruit volatile in combination with grandisoic acid. The fourth plot received grandisoic acid alone. In all, there were six replicates of each synthetic fruit volatile among the 12 orchards.

All traps were deployed at tight cluster or early pink (April 28-May 4). Traps were examined for captured PC beginning at petal fall (May 9) and every 3 to 4 days thereafter for 7 weeks until June 27. Vials of benzaldehyde and dispensers of grandisoic acid were renewed on May 28-30 (mid-way during the experiment). At each trap examination, 20 fruit on each of the six trapped trees per plot were examined for PC oviposition scars. All plots received two or three sprays of azinphosmethyl or phosmet to control PC.

Results

For PC captures summed across all three trap types (bottom of Fig. 1), results show that traps baited with grandisoic acid alone captured no more PCs than unbaited traps. Among the six synthetic fruit volatiles tested in combination with grandisoic acid, three captured about twice as many total PCs as did corresponding unbaited traps: benzaldehyde, ethyl isovalerate and limonene. For each of these three compounds, captures by baited pyramid traps were never more than twice as great as captures by unbaited corresponding pyramid traps, whereas captures by baited cylinder or Circle traps were always more than twice as great as captures by corresponding unbaited cylinder or Circle traps (Fig. 1). Owing to the limited number of replicates (six per treatment) and variability among replicates, there were no significant differences in PC response to baited versus unbaited traps,

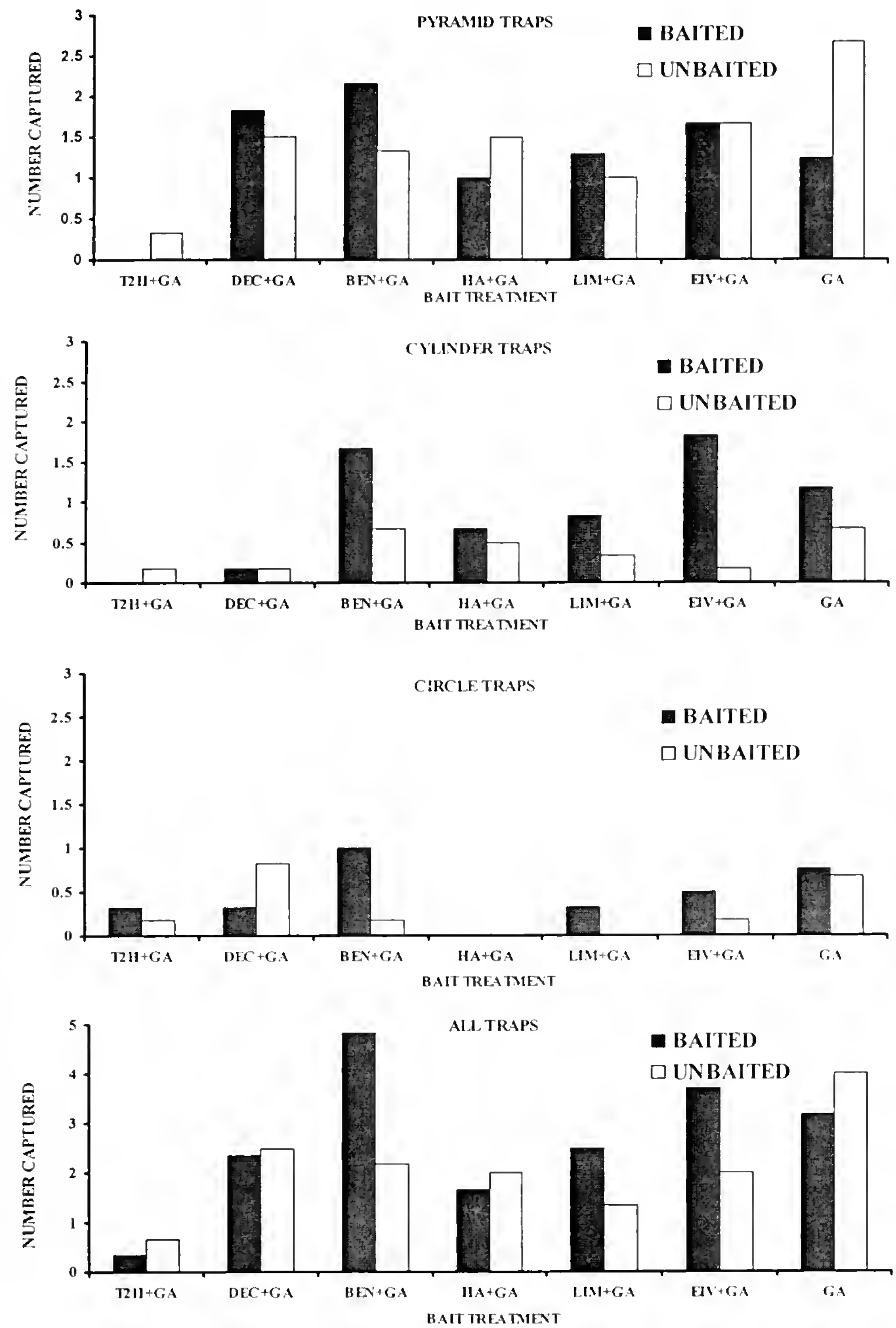

Figure 2. Captures of overwintered plum curculios by odor-baited traps placed beneath or within canopies of perimeter apple trees in commercial orchards from May 1-June 27, 2000. No significant differences at odds of 19:1 were detected for any paired comparisons involving an odor-baited treatment and its corresponding unbaited treatment. T2H= trans-2-hexenal, DEC= decanal, BEN= benzaldehyde, HA= hexyl acetate, LIM= limonene, EIV= ethyl isovalerate, GA= grandisoic acid

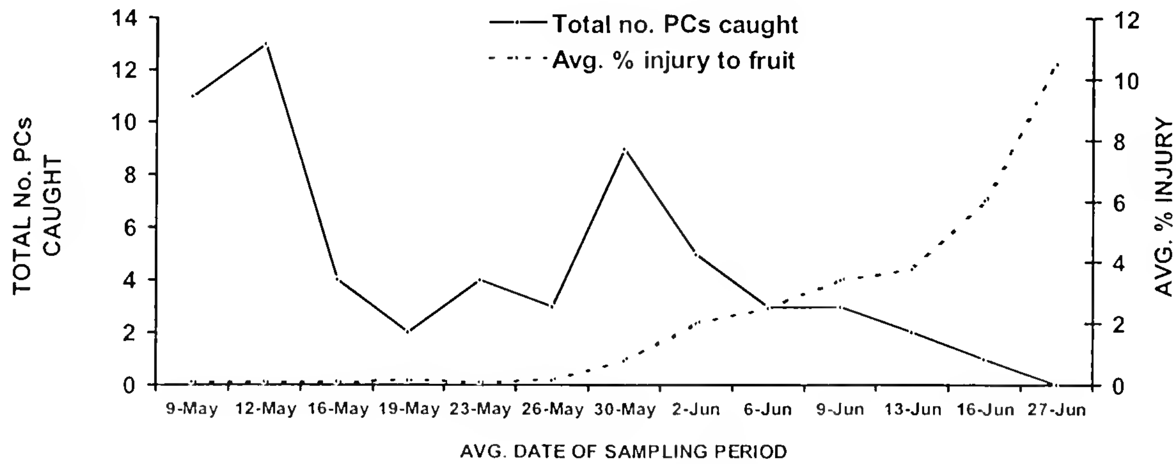

Figure 2. Relationship between combined captures of PCs on pyramid, cylinder, and Circle traps baited with benzaldehyde, ethyl isovalerate and limonene (in combination with grandisoic acid) and average percent fruit injury for each of the 13 sampling sates from May 9-June 27 in commercial orchards.

despite strong numerical trends. Traps baited with any of the remaining three synthetic fruit volatiles (decanal, hexyl acetate and trans-2-hexenal) in combination with grandisoic acid captured no more total PCs than corresponding unbaited traps (Fig. 1).

Table 1. Degree of correlation between time or amount of captures of PCs by pyramid, cylinder, or Circle traps baited with benzaldehyde, ethyl isovalerate, or limonene (each in combination with grandisoic acid) and PC injury to fruit in plots where traps were located in commercial orchards.

		Correlation r value*	
Odor	Trap	Time of capture vs. time of injury	Total capture vs. total injury
Benzaldehyde	Pyramid	0.30	0.97
	Cylinder	0.10	0.26
	Circle	0.70	0.51
Ethyl isovalerate	Pyramid	0.10	0.42
	Cylinder	0.10	0.10
	Circle	0.10	0.62
Limonene	Pyramid	0.33	0.98
	Cylinder	0.57	0.28
	Circle	0.22	0.99

*The value of r indicates the strength of correlation. Perfect correlation: r = 1.00 (or –1.00). Total absence of correlation

For a trap to have real value in monitoring PC abundance in a commercial orchard, trap captures ought to correlate well in time and total amount with time and total amount of PC injury to fruit. Fig. 2 shows that when capture data were summed across baited pyramid, cylinder and Circle traps and across benzaldehyde, ethyl isovalerate and limonene (in conjunction with grandisoic acid) as bait, periods of increase in trap capture were not well correlated with periods of increase in fruit injury. For example, average fruit injury increased successively from 0.78% to 10.50% of all fruit sampled during each sampling period from May 30 to June 27, but there was no corresponding successive increase in captures of PCs during this period by traps baited with these three compounds. Nor was there any significant correlation between phenology of PC trap captures (pattern of occurrence over time) and phenology of PC injury to fruit for any of the individual trap types baited with any of the individual synthetic fruit volatiles in combination with pheromone (Table 1). There was, however, a strong correlation between total

Table 2. Captures of PCs by all traps combined and percent of PC-injured fruit in relation to type of cultivar comprising perimeter-row trees and type of habitat bordering perimeter-row trees.

	Cultivars in perimeter rows		Adjacent habitat		
Category	Gala, Jonagold, Fuji	McIntosh, Empire	Open	Hedge	Woods
Number of orchards	6	6	4	4	4
Avg. no. trapped PCs per orchard	23.2	8.0	14.0	10.0	22.7
Avg. injury (%)	23.1	5.3	15.3	4.6	22.6

captures of PCs across the season and total amount of fruit injury (at season's end) for pyramid traps baited with benzaldehyde or limonene and for Circle traps baited with limonene (Table 1).

When effects of orchard architecture and outlying habitat are considered, results show that trap captures were about three times greater and fruit injury was about four times greater when Gala, Jonagold or Fuji trees comprised perimeter rows than when McIntosh or Empire trees comprised perimeter rows (Table 2). Also, we were surprised to find that trap captures and fruit injury on perimeter rows directly facing 100 or more yards of open space were nearly as great as on perimeter rows directly facing woods 10 yards or less away (Table 2).

Conclusions

Our findings indicate that PCs discriminate quite well between cylinder traps or Circle traps baited with benzaldehyde, ethyl isovalerate or limonene (each in combination with grandisoic acid) and corresponding unbaited traps. This is the first time anywhere that PCs have been found to respond in a substantial way to odor-baited traps placed in apple tree canopies. These results will serve as a springboard for future studies aimed at pinpointing the dose at which each of these three synthetic fruit volatile compounds is most attractive in association with cylinder or Circle traps. PCs did not discriminate as well between pyramid traps baited with these three compounds (in combination with grandisoic acid) and corresponding unbaited pyramid traps. Perhaps the location of the odor bait (at the top of a pyramid trap) was too far away from the point of PC entry (usually at the base of a pyramid trap) to be attractive, or perhaps the strong visual stimulus of a pyramid trap exceeded the stimulus of attractive odor.

Despite the progress in trapping PCs in commercial orchards reported here, we have not yet reached our goal of development of an odor-baited trap whose captures reflect both the timing and the amount of PC injury to fruit. Even so, the findings reported here represent progress toward this goal.

Finally, we were surprised by the much greater number of PC captures and amount of injury on perimeter Gala, Jonagold, and Fuji trees compared with perimeter McIntosh and Empire trees. We were also surprised by the large average amount of captures and injuries on perimeter trees facing open fields. Perhaps PCs are inmigrating into orchards from distances much further than we have recognized, and doing so especially in response to odor emitted from certain attractive cultivars. We plan to explore both of these aspects further in the coming year.

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Spatial Distribution of Plum Curculio Egglaying in Apple Trees

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Determining the distribution of initial and subsequent plum curculio (PC) damage inflicted upon fruit within host tree canopies could aid in optimal placement of traps for monitoring PC, especially placement of branch-mimicking cylinder traps. Such knowledge may also aid in devising sound protocols for monitoring sectors of host trees most prone to receiving PC damage. Studies performed in past years (nearly all in Quebec and predominantly with caged trees) have yielded valuable but somewhat inconsistent results (perhaps due to differences in tree size, tree phenology, or adult PC population density). It has been found, for example, that PC damage is greatest at tops of large apple trees, but for semi-dwarf caged trees, PC damage has been reported as concentrated toward the center of the canopy. Here, at approximately one-week intervals in 2000, we compared the spatial distribution of PC infestation of fruit of small, medium, and large apple trees.

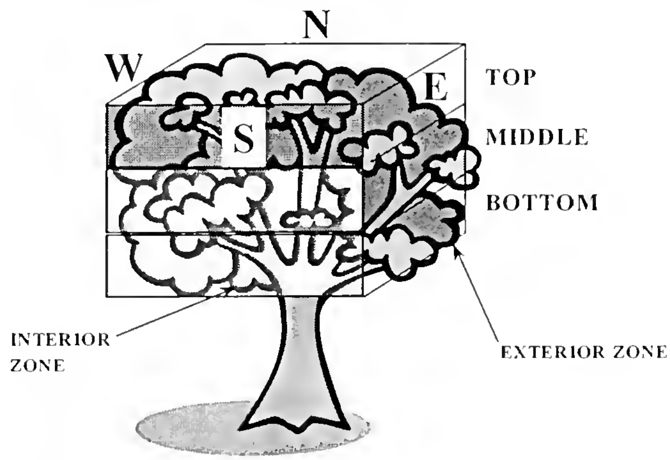

Figure 1. Representation of the subdivision of an apple tree canopy into three levels, showing the four limb orientations, and the exterior and interior zones of tree branches (only for medium and large trees). Twenty-four sampling points were used for medium and large trees and 12 for small trees.

Materials & Methods

Studies were conducted in unsprayed sections of two apple orchards (Horticultural Research Center and Atkin's Farm) located in Belchertown, MA. At the HRC, we sampled from six small (McIntosh/M.9) and four medium (Priscilla/M.26) trees. At Atkin's we inspected the fruit of six large (Cortland/M.7) trees. We divided tree canopies into bottom, middle, and top (vertical plane) sectors by selecting and marking branches at each level. Within each level, there were four branches, one each pointing West, South, North, and East. Each of the 12 branches per tree was in turn subdivided into an external and internal zone, except for small trees where (because of limited canopy breadth) fruit inspection was confined to the mid part of tree branches. This approach provided 24 sampling locations in large and medium trees and 12 sampling locations in small trees (Figure

Table 1. Schedule of fruit sampling (mean fruit diameter in parentheses).

Tree size	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Small	May 24 (6.5 mm)	May 31 (8 mm)	June 7 (10 mm)	---	---
Medium	May 23 (7 mm)	May 30 (10.5 mm)	June 9 (13 mm)	June 16 (22.5 mm)	June 22 (no meas.)
Large	June 2 (9 mm)	June 13 (no meas.)	June 20 (10.5 mm)	---	---

1). We inspected five fruit per sampling location (sector), recording the number of oviposition scars found on each fruit. Fruit inspection was conducted according to the schedule presented in Table 1. Fruit within a sector were sampled randomly on each sampling date. During the first two sampling dates, sampled fruit were mistakenly picked from small and medium trees. Thereafter, fruit were inspected *in situ* and remained on tree branches.

Results are presented in the form of mean number of oviposition scars per fruit and also as percentage of total fruit injured (fruit having at least one PC scar). Data were averaged across the number of replicates (trees) that comprised each treatment (tree size). Fruit were sampled on five dates for medium trees, and on three dates for small and large trees (because of the devastating impact of apple scab in mid- to late-June).

Results

Branch level. Distribution of PC damage according to branch level for each tree size and sampling date is depicted in Figure 2. For small trees, fruit damage was about the same for low, middle and top levels on each of the three sampling dates. For the first sampling, 3-8% of the fruit inspected had at least one oviposition scar. Percentages of fruit having one or more such scars increased gradually until reaching a maximum of 53-66% on the third (and last) sampling date. For medium trees, on the first sampling date, there were numerically but not significantly more PC scars on those fruit located at the top of the canopy. For sampling dates 2 and 3, oviposition scars were about evenly distributed among levels within the canopy. For sampling date 4, there were numerically but not significantly fewer scars near the top of the canopy, and during sampling date 5, fruit damage was significantly least at the top of the canopy. Percentages of fruit having at least one PC scar ranged from 6-16% for sampling dates 1 and 2, and increased substantially on the

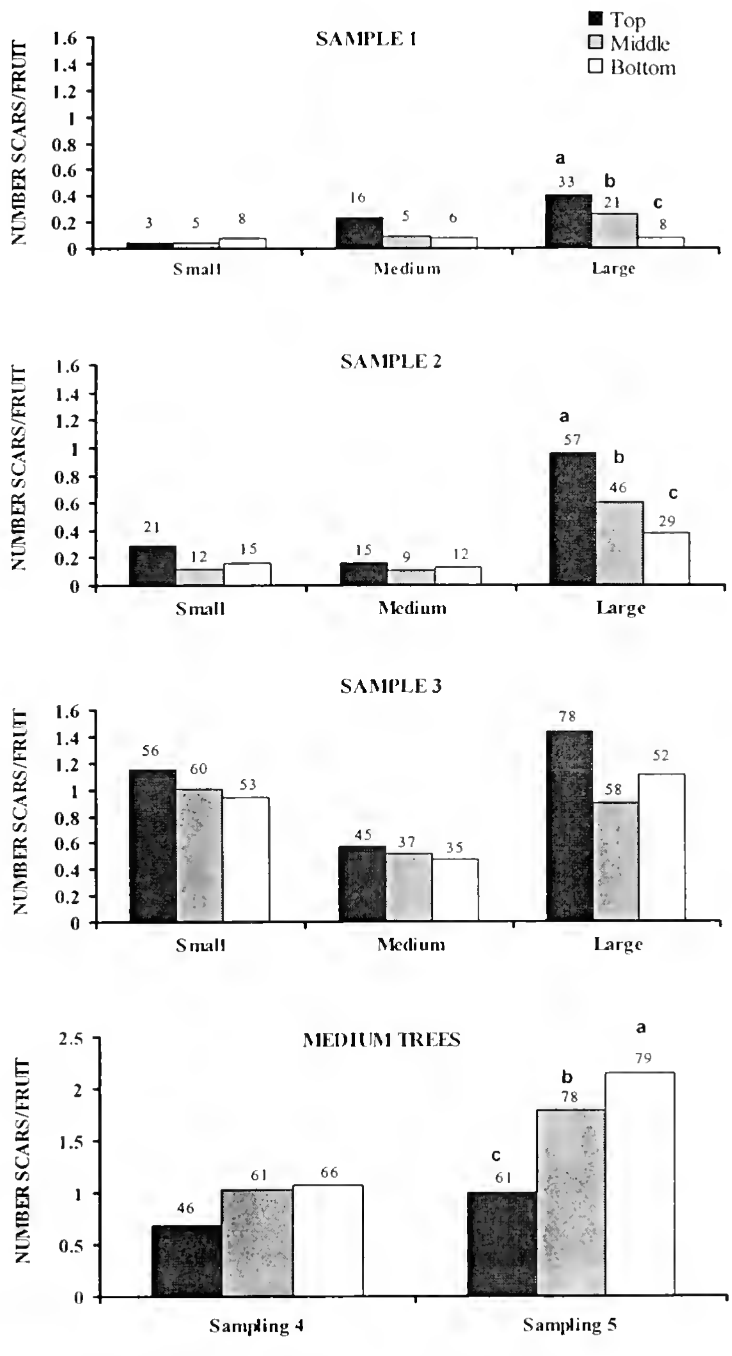

Figure 2. Distribution of the number of PC oviposition scars on fruit of small, medium and large trees according to branch level. Numbers above bars represent the mean percentage of fruit having at least one PC scar. Different letters above bars indicate significant differences among treatments at odds of 19:1. For sampling dates, see Table 1.

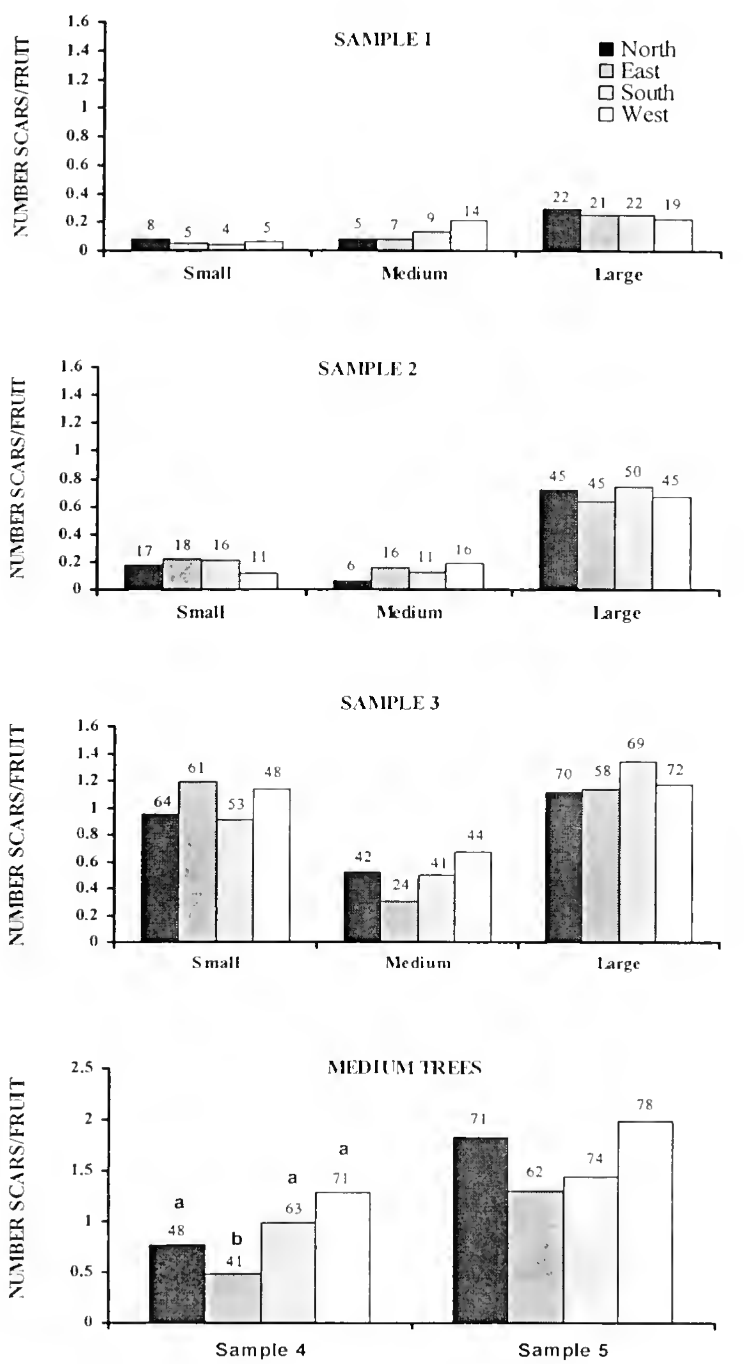

Figure 3. Distribution of PC oviposition scars according to branch orientation. Numbers above bars represent the mean percentage of fruit having at least one PC scar. Different letters above bars indicate significant differences among treatments at odds of 19:1. For sampling dates, see Table 1.

third sampling date (35-45%). Maximum percentage of fruit having one or more oviposition scars was reached on sampling date 5: 78 and 79% damaged fruit for the middle and bottom canopy levels, respectively. For large trees, oviposition scars were significantly greatest in the top level of tree canopies during all three sampling dates. Distribution of fruit having at least one PC scar also followed this pattern.

Branch orientation. Distribution of PC oviposition scars according to branch orientation for each tree size and sampling date is depicted in Figure 3. No significant differences in numbers of scars were found among branches oriented North, East, South and West on the first three sampling dates. Nor were there any obvious numerical trends. Across sampling dates 3, 4, and 5 for medium trees, however, fruit injury was consistently least on branches oriented East and greatest on branches pointing West. Percentages of fruit showing injury followed this same pattern.

Branch zone. For small trees, branches were not subdivided into exterior or interior zones. For medium trees, there were no significant differences in numbers of scars present on fruit located at exterior vs. interior zones of branches, regardless of branch level or sampling date (Figure 4). There was, however, a consistent numerical trend across all sampling dates (for both numbers of scars and percent fruit injured) toward greater PC damage on exterior than interior fruit at tree tops. There was no such consistent trend across sampling dates in the case of middles or bottoms. For large trees, for the first sampling date, scars were distributed similarly between interior and exterior zones of branches regardless of branch level (Figure 5). However, for sampling dates 2 and 3, infestation was significantly greater at the exterior zone of branches when branches were located in the top part of the tree. No significant differences in infestation levels were found between exterior vs. interior zones of branches located in the middle part of the tree canopy. For branches at the bottom part of the canopy, there was a notable numeri-

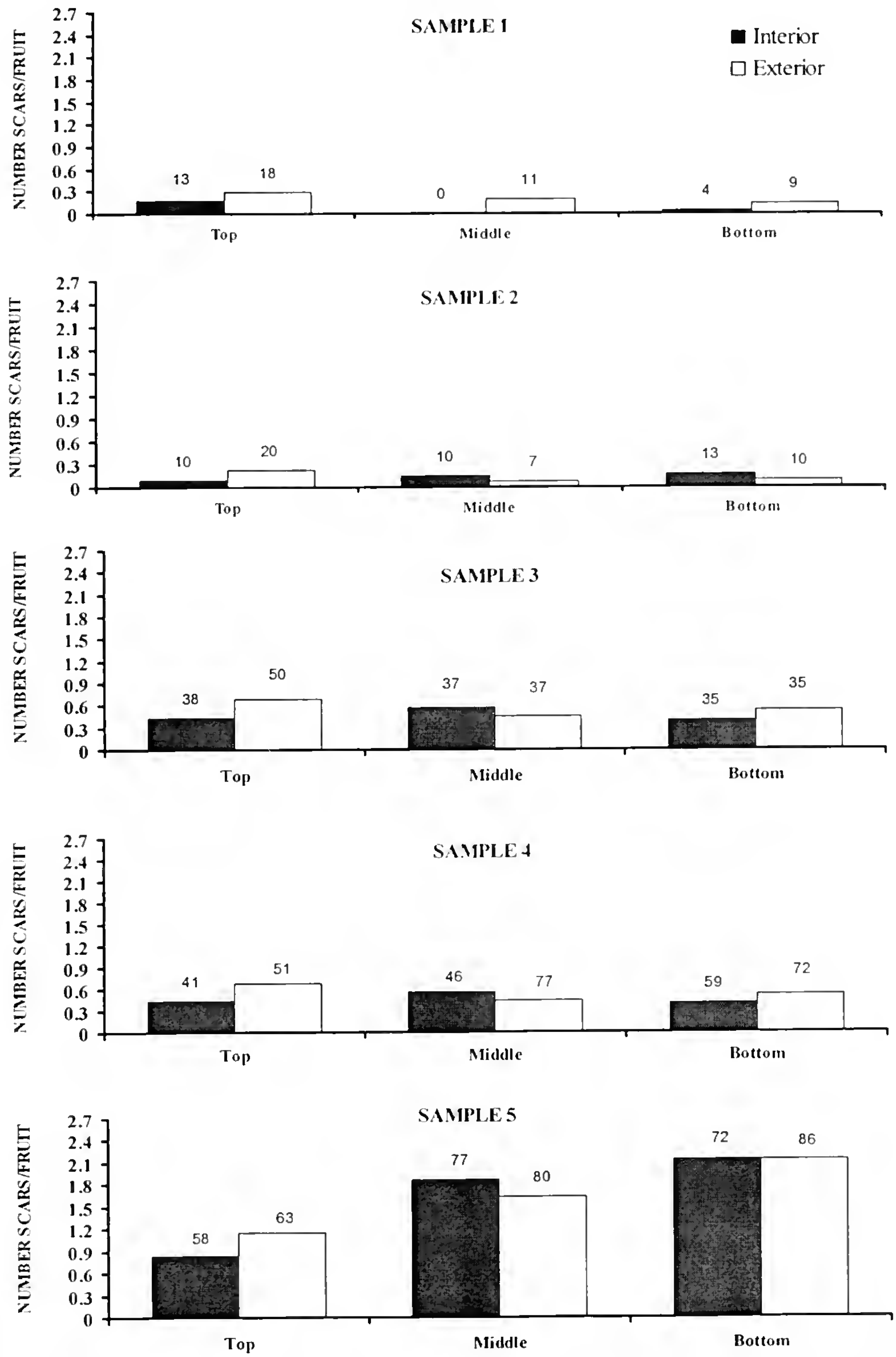

Figure 4. Distribution of PC oviposition scars on fruit located in external vs. internal zones of branches of medium trees. Numbers above bars represent the mean percentage of fruit having at least one PC scar. For sampling dates, see Table 1.

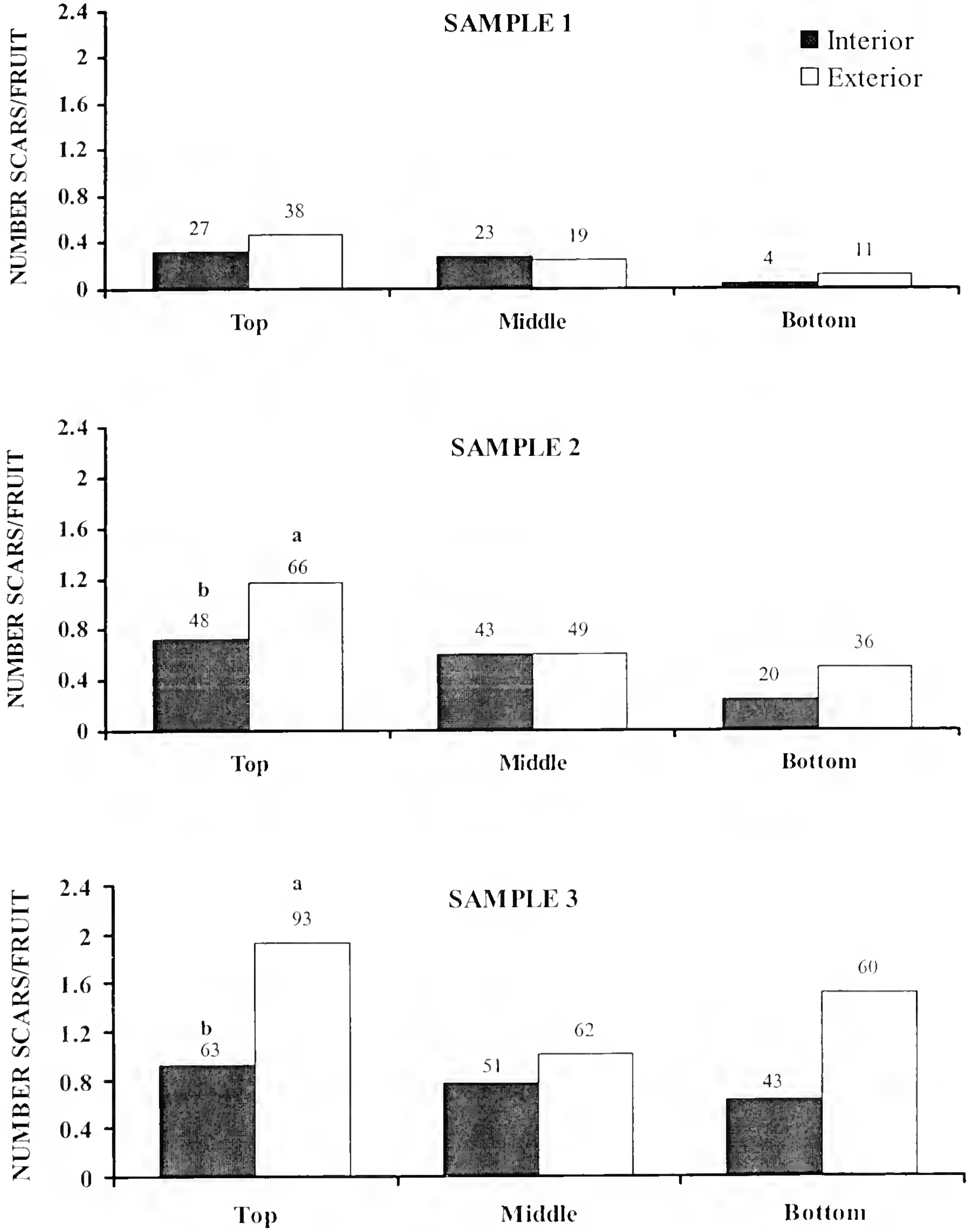

Figure 5. Distribution of PC oviposition scars on fruit located in external vs. internal zones of branches of large trees. Numbers above bars represent the mean percentage of fruit having at least one PC scar. Different letters above bars indicate significant differences among treatments at odds of 19:1. For sampling dates, see Table 1.

cal trend toward successively greater PC damage on exterior compared with interior zones as the season progressed (Figure 5).

Conclusions

Results suggest that PC infestation patterns vary according to tree size and sampling date, which is directly related to phenological stage of fruit development. With respect to the vertical plane of tree branches, results for large trees suggest greater damage (expressed as numbers of scars and percentages of injured fruit) at the tree top on all sampling dates, coinciding with previous reports of other researchers who found that PC scars in scout (Granny Smith) apples were detected only in the upper halves of large (McIntosh and Cortland) trees. For medium trees, the latter was true during the first sampling date, although differences were not significant. Our findings of a rather uniform infestation pattern among sectors of small trees does not concord with a report by Chouinard and collaborators (1994), who showed that in Quebec, PC oviposition scars were most abundant at the middle-level of small apple trees.

With respect to orientation of branches of small and large trees, our findings are in agreement with those of Le Blanc and collaborators (1984), who found no differences in oviposition scar frequencies according to the four cardinal points of the compass. For branches of medium trees during samplings 4 and 5, oviposition scars were most abundant on the West side of tree crowns. This location corresponds to the area where substantially more PC adults were found present at sunset (time of day when most oviposition activities occur), as confirmed by branch tapping performed on medium-sized trees on different days.

Determination of PC infestation patterns on exterior vs. interior zones of tree branches is an aspect that has not been evaluated heretofore. In general, no significant differences in PC damage were found for external vs. internal zones of branches of medium or large trees. However, as the season progressed, external zones of branches located at tops of both medium and large trees seemed to be the most prone to PC injury.

We used two indicators of PC injury because total numbers of PC scars may not correlate directly with numbers of fruit injured given that multiple wounds on a single fruit may be inflicted by either a single PC or multiple PCs. For the most part, these indicators were consistent with each other in our study. Our next step will be to determine if there is a correlation between fruit damage and numbers of PC adults captured by branch-mimicking black cylinder traps placed in different tree sectors. This will allow us to determine the best trap position within host tree canopies for the capture of PCs.

We conclude that damage to fruit by PCs is more likely to occur at the tops of large (and possibly medium) trees, particularly early in the season, with no influence of branch orientation. As the season progresses, external zones of branches located at tree tops become more prone to attack by PC than do internal zones of branches.

Acknowledgments.

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References Cited

Chouinard, G., Hill, S.B., and Vincent, Ch. 1994. Spatial distribution and movements of plum curculio adults within caged apple trees. Entomologia Experimentalis et Applicata 70: 129-142.

Le Blanc, J.-P.R., S.B. Hill, and R.O. Paradis. 1984. Oviposition in scout-apples by plum curculio, Conotrachelus nenuphar (Herbst) (Coleoptera: Curculionidae), and its relationship to subsequent damage. Environmental Entomology 13: 286-291.

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Using Odor-baited Traps to Capture Immigrating Plum Curculios

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To determine extent and timing of plum curculio (PC) immigration from woods (overwintering sites) into apple orchards, we have focused in recent years on the development of different types of unbaited (1997-1998) and baited (1999) traps. We have found that black pyramid traps (mimicking tree trunks) and clear Plexiglas panels (for capture of flying PCs) baited with some components of the odor of unripe plum or apple fruit may hold considerable potential as devices for monitoring immigrating PCs.

Here, we present findings of a 2000 study aimed at determining the response of PCs to these two trap types baited with the most attractive synthetic fruit volatiles evaluated in previous years (each in combination with grandisoic acid, a synthetic male-produced pheromone that is attractive to adults of either sex) or pheromone alone.

Materials & Methods

The study was performed in an unsprayed section of a commercial apple orchard at the University of Massachusetts Horticultural Research Center (Belchertown, MA). We evaluated two trap types: (a) clear Plexiglas panels (2 x 2 feet) coated with Tangletrap on the woods-facing side and attached vertically to a wooden post (5.5 feet) secured in the ground (Figure 1), and (b) black pyramid traps (24 inches wide at base x 48 inches tall) capped with an inverted screen funnel (boll weevil trap top). Our purpose in deploying these two types of traps was to capture adults immigrating from woods by flight (panel traps) or crawling (pyramid traps), as PC adults may exhibit either flight or crawling as means of displacement during orchard colonization (depending largely upon weather conditions).

Each trap was baited with one dispenser containing pheromone and one of the following six synthetic fruit

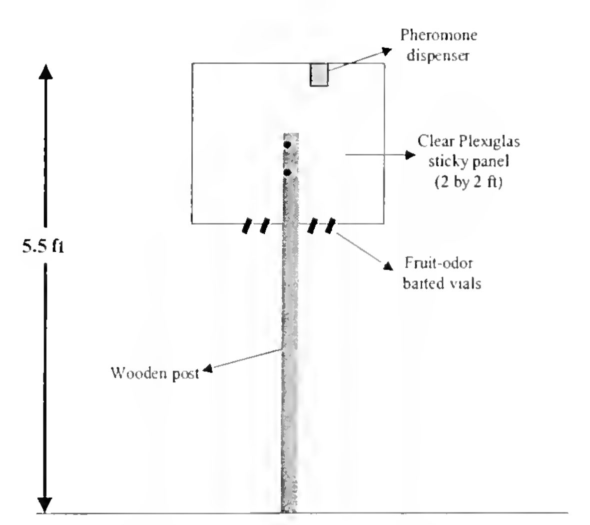

Figure 1 Schematic illustration of a baited panel trap.

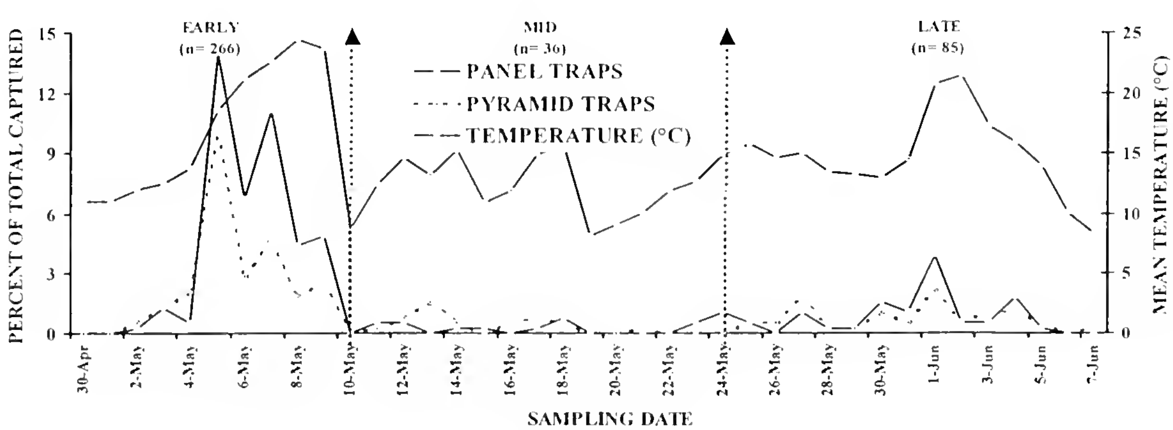

Figure 2. Percent of seasonal total number of adult PCs captured per day by baited panel and pyramid traps. Mean temperature at study site is lso shown.

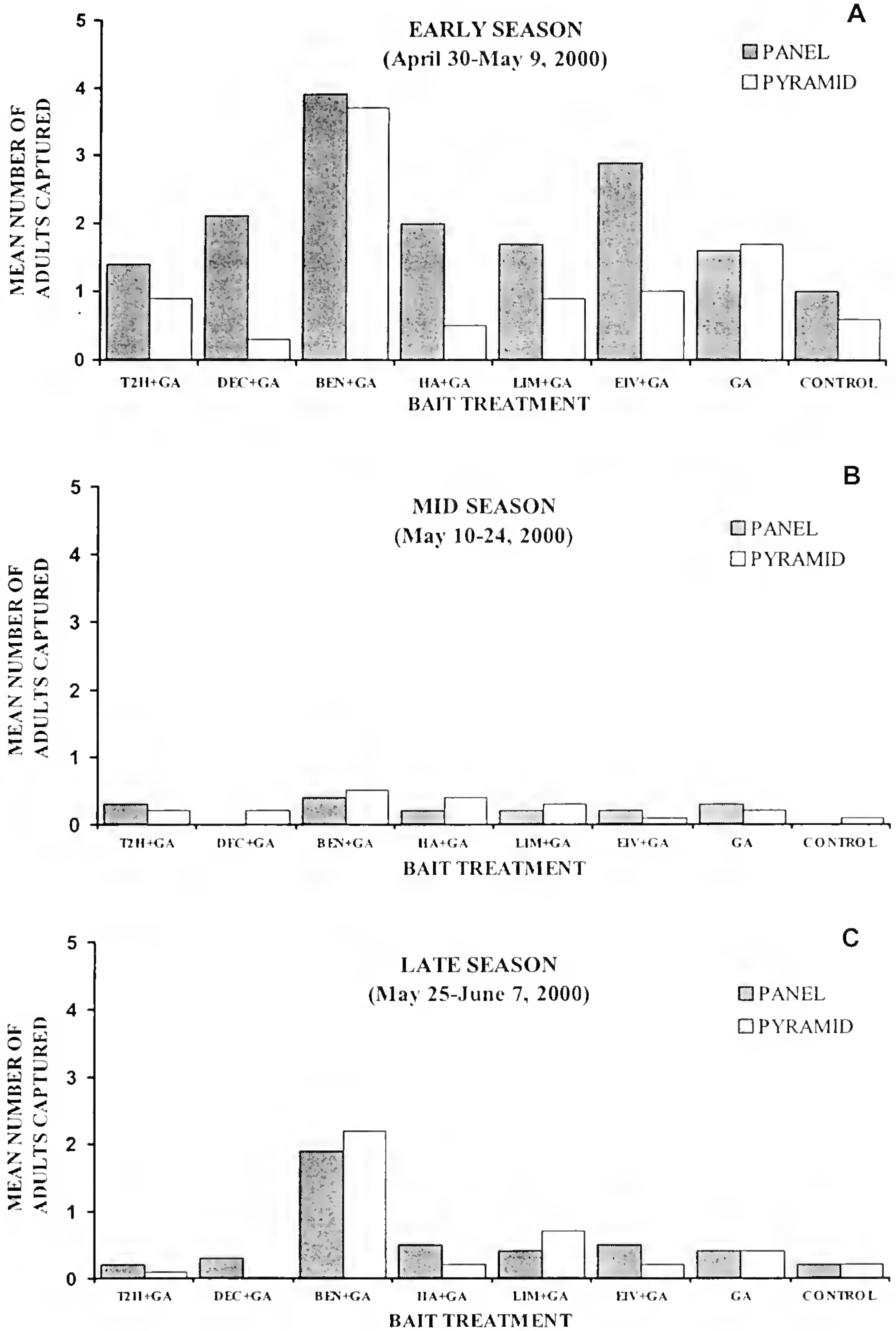

Figure 3. Number of adult PCs captured by baited or unbaited panel and pyramid traps during: (A) early season, (B) mid season, and (C) late season.

volatiles: benzaldehyde, decanal, E-2-hexenal, ethyl isovalerate, hexyl acetate, or limonene, each contained in polyethylene vials. As reported in the summer 1999 issue of *Fruit Notes*, each of these fruit volatiles has been found to be attractive to PCs when evaluated in association with boll weevil traps placed on the ground beneath host trees. We also evaluated pheromone alone and an unbaited (control) treatment. Depending on the volatile type, a different number of vials (2-5) was needed to achieve a release rate of 10 mg per day. For panel traps, vials containing fruit volatiles were attached to the lower edge of the Plexiglas panels, and one pheromone dispenser was attached to the upper edge. For pyramid traps, vials containing volatiles and one pheromone dispenser were placed inside each boll weevil trap top capping a pyramid trap. Vials containing benzaldehyde and limonene, as well as grandisoic acid dispensers, were replaced on May 24 (beginning of fruit set), because endurance of these compounds under the weather conditions of this study was shorter than that estimated in the laboratory.

On April 30 (tight cluster stage of bud development), 40 clear Plexiglas panels and 40 pyramid traps were positioned in close proximity to woods (overwintering sites adjacent to apple trees) and remained there until June 7 (end of fruit-set stage). Traps were arranged in five groups of 16 traps each (dictated by the combination of eight odor treatments and two trap types) and were deployed in pairs, with one trap of each type (bearing the same odor treatment) placed 1 m apart. Each pair was separated by 10 yards. Traps were inspected every morning (at 7:30 AM) throughout the study.

Results

Based primarily on phenological stage of apple bud and fruit development, PC immigration was divided into early-, mid- and late-season periods (tight cluster to bloom, petal fall, and fruit set, respectively). Overall, 387 PCs were captured by traps during the 39-day study period. First PC captures by traps (3 PCs) occurred on May 2. Peak of adult immigration was observed on May 5 (93 PCs, corresponding to 24% of the season-long total, were captured by traps on this particular day). Periodic peaks of adult captures by traps seemed to coincide with rises in temperature (Figure 2), a factor that has been shown to influence both the emergence of adults after overwintering and the appearance of adults in host trees.

During early-season (April 30-May 9), 266 adults (69% of total) were captured by traps. Over this period, panel traps baited with benzaldehyde plus pheromone or ethyl isovalerate plus pheromone were about four-fold and three-fold, respectively, more attractive to PCs than were unbaited panel traps, and pyramid traps baited with benzaldehyde plus pheromone or pheromone alone were about six-fold and three-fold, respectively, more attractive than were unbaited pyramid traps (Figure 3a).

During mid-season (May 10-24), only 36 PCs (9% of total) were captured by traps, and there was little response of PCs to traps of any type (Figure 3b), possibly on account of prevailing cool weather unfavorable for adult activity.

During late-season (May 25-June 7), 85 PCs (22% of total) were caught by traps. We found that just after replacing vials containing benzaldehyde and pheromone dispensers, panel and pyramid traps baited with benzaldehyde plus pheromone were again much more attractive (six-fold and eleven-fold, respectively) to PCs than any other traps (baited or unbaited) of either type (Figure 3c).

Conclusions

This study represents a step toward development of a more efficient monitoring tool for PC. By placing panel and pyramid traps baited with benzaldehyde in combination with pheromone in close proximity to woods, we were able to determine the first arrivals of PCs in the orchard (during tight cluster), as well as the peak (during full bloom) and possible end (during fruit set) of PC immigration. Benzaldehyde plus pheromone proved to be the most attractive lure during early season and also during late season. We believe that lack of attractiveness of benzaldehyde plus pheromone over the 15 days that comprised the mid-season period could have been due, in part, to impact of low temperatures on level of adult activity but also in part to loss of activity of pheromone and altered activity of benzaldehyde, perhaps during the warm days that characterized the preceding early-season period. If the latter is true, then we need to investigate a better way of dispensing benzaldehyde to ensure stability and longevity at a desired release rate.

We conclude that panel and/or pyramid traps baited with benzaldehyde plus pheromone deployed at borders of plum curculio overwintering sites, particularly near areas of orchards where the greatest plum curculio injury occurs, as determined by previous experience, can be a valuable tool for identifying the pattern of PC immigration. This can aid in accurate timing of insecticide application. The next step will be to work with combinations of odor volatiles, different release rates, and trap placement in order to improve performance of the traps.

Acknowledgments

We thank Russ Fleury, Brad Chandler, Katie Bednaz, Amanda Ross, Tracy Leskey, and Juan Rull for assistance. Funds for this work were provided by a USDA Northeast Regional IPM grant, a Hatch grant, and the New England Tree Fruit Research Committee.

Pursuit of Effective Pesticide-treated Spheres for Controlling Apple Maggot

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For many years, we have reported in *Fruit Notes* progress toward development of effective trapping systems for behavioral control of apple maggot fly (AMF). Until recently, the bulk of this research has been built upon deployment of sticky-coated red spheres for direct control of AMF. Exhaustive field research has convincingly shown that surrounding mid-sized blocks (trials performed in plots up to ~ten acres) with odor-baited sticky red spheres (five yards apart) to intercept immigrating AMF can provide very good control without need for summer insecticides. However, the sticky material used to trap and kill alighting AMF is very difficult to handle and requires frequent maintenance to ensure trap effectiveness.

To address this shortcoming, we have developed and tested a series of prototype pesticide-treated spheres (PTS) to substitute for cumbersome sticky-coated spheres. In concept, AMF land on a PTS, receive a toxic dose of insecticide, and die. However, consistent lethality to AMF can only be assured if flies are strongly induced to feed upon the sphere surface and ingest a very small (but lethal) dose of insecticide. Because of this, PTS must maintain a detectable residue of feeding stimulant (such as sucrose) associated with toxicant at the sphere surface. Unfortunately, under conditions of rainfall, both insecticide and sucrose lose residual activity very quickly. Latex paint is very effective in preserving residual activity of insecticide—we have evaluated all orchard-labeled insecticides and have found imidacloprid (Provado) to be the most toxic to AMF at a very low dose in latex paint. In fact, a dose of 2%-4% (a.i.) imidacloprid in latex paint is sufficient to kill 80% of flies alighting on wooden PTS after 12 weeks of field exposure (and 12 inches of rainfall), provided that PTS have been retreated with feeding stimulant. Thus, the key to successful development of commercially viable PTS for direct control of AMF lies in maintaining the residual effectiveness of sucrose on spheres under field conditions. Although the problem can be stated simply (maintain sugar on spheres throughout a northeastern summer), we have struggled for many years to achieve a firm solution.

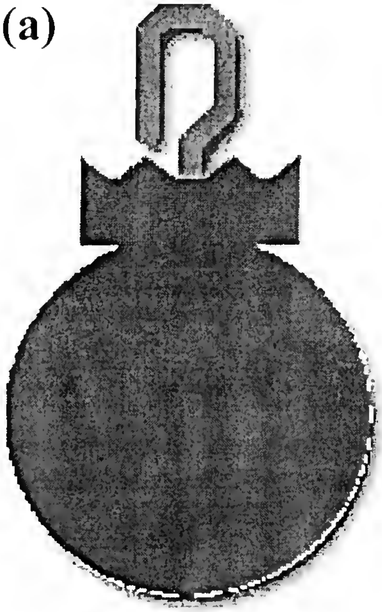
Materials & Methods

We have developed two approaches to providing a continuous supply of sucrose on the surface of a PTS to ensure fly feeding and consistent toxicity to AMF. In 1999, we developed a prototype disc comprised of sucrose bound in paraffin wax that is placed atop a wooden PTS (as described in *Fruit Notes*, Fall 1999). Under rainfall, sugar is distributed along with water onto the sphere surface, renewing sucrose lost from the sphere surface during runoff. For deployment in 2000, we modified these sucrose/wax caps in three major ways: (a) we doubled the mass of the cap to 50 grams to extend the endurance of each cap; (b) we increased the diameter to 2 in. (from 1.25 in.) to maximize surface area and sucrose output; and (c) we designed a hydraulic mold system that presses eight flutes into each cap to ensure uniform distribution of sucrose-bearing runoff.

Our second approach involved a collaborative effort (with the USDA lab at Peoria, IL) toward development of a sphere whose entire body consists of a mixture of sugar and starches (as reported in *Fruit Notes*, Fall 1997), such that under rainfall, sugar is emitted through the latex paint onto the sphere surface. Both of these sphere types have undergone extensive laboratory testing, revision, and fine-tuning in the past several years. Here, we report on commercial-orchard trials of our best versions of each sphere type for the 2000 growing season.

In 28 small plots (~49 trees each) of apple trees across seven commercial orchards, we compared the effectiveness of our newest versions of PTS (Figure 1) against sticky spheres and insecticide sprays for control of AMF. Both wooden and sugar/flour PTS were treated with latex paint containing 2% (a.i.) imidacloprid. For this trial, three plots per orchard were equipped with spheres positioned about five yards apart on all perimeter trees, and one grower-sprayed plot served as the orchard control. One plot of each experimental treatment was emplaced in each orchard: (a) wooden PTS bearing a 50 gram cap of 85% sucrose:15% paraffin wax (each cap 2 in. diameter, fluted for even runoff distribution); (b) sugar/flour PTS produced by a private manufacturer (FruitSpheres Inc.), distributed alternately with either black or red paint (to gauge rodent-deterrent effects of sphere color); (c) sticky-coated wooden spheres; and (d) two to three insecticide sprays. Caps atop wooden spheres and all sugar/flour spheres were replaced at mid-season (after six weeks of field exposure) with fresh versions of each. Treatment effectiveness was judged by comparing numbers of feral AMF

(a)



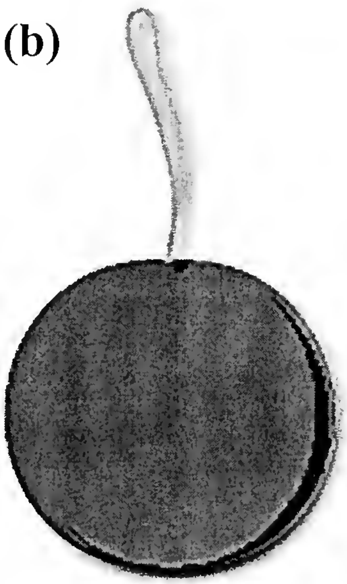
Wooden Pesticide-Treated Sphere

Sphere Body: 8.4-cm wooden sphere.

Feeding Stimulant: 42.5g sucrose bound with 7.5g paraffin. Ingredients are heated to 302°F, granulated, and pressed to form 2" caps with 8 flutes. Sugar is released from the top of the sphere during rainfall.

Surface: Red latex paint containing 2% (a.i.) imidacloprid.

(b)



Sugar/Flour Pesticide-Treated Sphere

Sphere Body: 7.7-cm sphere, consisting of the following: 38g water, 90g sugar, 83g corn syrup, 158g corn flour, 3.7g Cayenne pepper, 0.4g sorbic acid.

Feeding Stimulant: 173g sucrose and fructose bound in sphere body. Sugar is released from the body of the sphere during rainfall.

Surface: Red latex paint containing 2% (a.i.) imidacloprid.

Figure 1. Schematic illustrations of PTS used in 2000: (a) wooden PTS bearing a sugar/wax cap, and (b) sugar/flour PTS.

captured on interior unbaited monitoring traps (four traps on central trees of each plot) and percent injury to fruit in samples taken five times from July to September.

In addition to measurements of whole-plot treatment effectiveness, we assessed the structural durability of each PTS type bi-weekly from June to September. For these assessments, we recorded the percentage of spheres impacted by the two most commonly damaging influences: feeding on caps or spheres by rodents and mold growth on sphere surfaces. For each of four sample sites, we also recorded the amount of rainfall accumulated during each sample period as a factor potentially leading to premature breakdown of sphere effectiveness (through wash-off of sugar and/or toxicant).

At the mid-point (6 weeks of field exposure) and end (12 weeks of field exposure) of the trial, we retrieved indi-

Table 1. Captures of feral AMF on unbaited monitoring traps and percent injury to fruit by AMF in 28 plots of apple trees in seven commercial orchards.

Treatment	No. AMF captured per plot*	Fruit injury per plot (%)
Wooden PTS	21.8	0.003
Sugar/flour PTS	25.8	0.016
Sticky Spheres	33.2	0.006
Insecticide Sprays	21.7	0.011

* Four unbaited spheres per plot

vidual PTS of each type from each orchard and returned them to the laboratory for testing. We directly assessed the residual fly-killing power of each PTS type by exposing 20 AMF to each sphere type from each orchard. Each sphere was tested twice: immediately upon return from the field (with no supplemental feeding stimulant), and again after application of a 20% sucrose solution to stimulate fly feeding. Fly residence time on spheres and fly condition (alive or dead) 72 hours post-exposure were recorded for each fly. In all, we tested 2240 AMF (individually) on a total of 224 PTS.

Table 2. Percentage of PTS receiving greater than 20% damage by rodent feeding, based on visual inspection (bi-weekly) of 180 spheres of each type.

Weeks of field exposure	Spheres damaged by rodent feeding (%)*	
	Wooden PTS	Sugar/flour PTS
2	7.0	2.0
4	14.7	14.0
6	20.5	35.4
All sugar/wax caps and sugar/flour spheres replaced at mid-season.		
2	27.1	26.6
4	29.6	37.5
6	31.4	43.7

* Loss of 20% or more surface area (sugar/flour PTS) or mass (sugar/wax caps).

Results

Treatment Effectiveness. Comparisons of AMF captures on unbaited monitoring spheres on interior trees of each plot (Table 1) show that the number of AMF that penetrated into plots surrounded by wooden PTS was no greater than the number that penetrated into plots that received two to three insecticide sprays. Although differences were slight, wooden PTS actually numerically outperformed both sugar/flour PTS and sticky spheres. Fruit damage levels between plots were very difficult to compare and were not particularly reliable for this trial, given the near total lack of AMF damage in any plot. Even so, wooden PTS performed as well as or better than any other treatment.

Structural Integrity. In order for spheres to maintain effectiveness throughout a field season, they must be somewhat resistant to naturally damaging in-orchard influences, particularly rodents and mold. Results from this trial clearly indicated that no advantage in combating these influences was gained by altering sphere color from red to black. Therefore, all results focus only on structural integrity of wooden PTS versus sugar/flour PTS (pooled data from red and black spheres).

Through the years of development of PTS, feeding by rodents on spheres has been a significant obstacle to large-scale implementation. After only 4 weeks of field exposure (Table 2), 14.7% of caps atop wooden PTS had lost 20% or more of their mass to rodent feeding. Similarly, after the same period, 14% of sugar/flour spheres had lost 20% or more of their surface area to rodent consumption. Destruction of both sugar/wax caps (wooden PTS) and sugar/flour PTS by rodents increased in intensity as the season progressed, reaching 20.5% and 35.4% rodent damage, respectively, after 6 weeks of field exposure. After 6 weeks of exposure, all sugar/flour spheres and all caps atop wooden spheres were replaced. Unfortunately, the trend of rodent feeding established in the first half of the season continued until trap removal after 6 additional weeks of exposure. During this interval, 31.4% of caps on wooden PTS lost 20% or more of their mass to rodents, faring only slightly better than sugar/flour PTS (43.7% losing 20% or more surface area).

Table 3. Percentage of PTS exhibiting growth of mold on the sphere surface, based on visual inspection (bi-weekly) of 180 spheres of each type. Rainfall was sampled hourly at four regional sites: Deerfield, Belchertown, Sterling, and Northboro.

		Spheres with mold growth (%)	
Weeks of field exposure	Mean rainfall (inches) per 2-week period	Wooden PTS	Sugar/Flour PTS
2	0.47	0.0	0.0
4	3.60	1.2	32.7
6	3.00	1.3	61.0
All sugar/wax caps and sugar/flour spheres replaced at mid-season.			
2	0.71	0.0	2.9
4	1.13	13.2	12.8
6	1.32	13.6	26.2

Growth of mold on spheres (Table 3) was found to occur more commonly on sugar/flour PTS than on wooden PTS. This was a logical finding, given that the entire bodies of sugar/flour spheres were constructed of food products (with a small dose of preservative), all of which were subject to mold growth. Through mid-season (six weeks), very few wooden PTS exhibited significant mold growth (1.3%). In fact, only 13.6% of wooden PTS in place through the entire 12-week trial had any mold present on the sphere surface. For sugar/flour PTS, a great number of spheres exhibited mold growth through 4 weeks (32.7%) and 6 weeks (61.0%) of field exposure, at which point all spheres were replaced. In the second 6-week interval, fewer (26.2%) sugar/flour PTS developed mold, likely owing to greatly reduced rainfall and humidity in the second half of the season (Table 3).

Residual Toxicity. After 6 weeks of field exposure (Table 4), neither wooden PTS nor sugar/flour PTS provided an acceptable level of AMF mortality (30.7% and 26.5% kill, respectively) prior to addition of feeding stimulant. The implications of these data are humbling, suggesting that after 6 weeks of field exposure, PTS of either type were lethal to less than one-third of arriving flies. Upon re-treatment of spheres with feeding stimulant, mortality of AMF after exposure to wooden PTS was very good (75.7%). However, sugar/flour spheres had apparently lost a substantial amount of toxicant (possibly lost to heavy rainfall in the first half of the season), still yielding an unacceptable level of AMF control (44.6%).

As mentioned in the previous sections, we replaced all sugar/flour PTS at the mid-point of the season; wooden spheres were left in place for the balance of the 12-week season and only the sugar/wax caps were replaced. After an additional 6 weeks of field exposure (Table 5), performance of wooden PTS was nearly identical to performance at mid-season: 41.4% kill of exposed AMF prior to re-treatment with

Table 4. Mortality of AMF after exposure to PTS. All PTS were retrieved from commercial orchards at the mid-point of the season (six weeks field exposure). AMF were exposed (individually) to each treatment and allowed to forage freely for up to ten minutes.

	AMF mortality (%) 72 hours after exposure to:		
Treatment	Wooden PTS	Sugar/Flour PTS	Control
No sugar applied prior to fly exposure	30.7	26.5	2.1
20% sugar solution applied prior to fly exposure	75.7	44.6	0.0

Table 5. Mortality of AMF after exposure to PTS. All PTS were retrieved from commercial orchards at the end of the season (six weeks field exposure for starch/flour PTS, twelve weeks field exposure for wooden PTS). AMF were exposed (individually) to each treatment and allowed to forage freely for up to ten minutes.

	AMF mortality (%) 72 hours after exposure to:		
Treatment	Wooden PTS	Sugar/Flour PTS	Control
No sugar applied prior to fly exposure	41.4	45.7	0.0
20% sugar solution applied prior to fly exposure	75.0	67.0	3.0

sugar. Performance of sugar/flour PTS in this interval was slightly better than in the initial 6-week trial, yielding 45.7% kill prior to re-treatment with sugar. After spheres received sugar treatment, wooden PTS rebounded to 75.0% effectiveness, again outperforming sugar/flour PTS (67.0% kill of exposed AMF). Taken together, it is quite clear that sugar/flour PTS are prone to lose toxicity over time (particularly under heavy rainfall), while wooden PTS can retain a high level of toxicity for a longer period under relatively adverse field conditions.

Conclusions

If we focus on field performance of this season's PTS and gauge their promise only on the basis of monitoring sphere captures and fruit damage, both wooden PTS and sugar/flour PTS appear to be highly effective in controlling AMF. In fact, this is the first season in which any PTS has outperformed (numerically, though not statistically) sticky spheres or insecticide sprays in an extended field trial. Although these data are encouraging, we believe that they are also somewhat deceiving, given the statewide dearth of AMF this season.

In this study, it is much more revealing to focus on the field/laboratory aspect of residual toxicity, bearing in mind that our goal is to develop a PTS that provides 80%-90% kill of arriving AMF without manual re-treatment with feeding stimulant. In this context, neither PTS type approached optimal efficacy. However, this study provided key information to aid in further development of PTS. It appears that as the season progresses, wooden PTS fitted with sugar/wax caps do not retain enough sugar to stimulate consistent fly feeding after 4 to 5 inches of rainfall. After re-treatment with sugar, wooden PTS return to their original toxicity. Sugar/flour PTS, on the other hand, appear to actually lose toxicant under field conditions, meaning that the spheres are inherently less effective against AMF in mid- to late-season (the period of greatest AMF risk).

Given these data, the focus of our research has shifted markedly toward further development of wooden PTS that can endure a full northeastern growing season, fitted with sugar/wax caps designed to be replaced once during the season (see following article). Overall, we are encouraged by the results of this commercial-orchard field trial, and remain optimistic about the potential of PTS technology for control of AMF.

Acknowledgments

We are very grateful to the seven growers who allowed us to deploy traps in their orchards: Dave Chandler, Aaron and Dana Clark, Tony Lincoln, Wayne Rice, Dave Shearer, Joe Sincuk, and Mo Tougas. Sugar/flour PTS were provided by FruitSpheres Inc. in conjunction with Robert Behle of the USDA NCAUR facility in Peoria, IL. This project was supported by state and federal IPM funds, along with grants from the Massachusetts Society for Promoting Agriculture and the US EPA IR-4 Program.

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FQPA-related Pesticide Residue Study, 1999

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Over the past several years, Members of the UMass Fruit Team have endeavored to provide information to Massachusetts fruit, vegetable, and berry growers as well as other pesticide applicators on developments associated with implementation of the Food Quality Protection Act of 1996 (FQPA). For fruit growers, this role has taken the form of multiple slide presentations at twilight meetings and annual updates in the March Message to Massachusetts fruit growers. These activities have also benefitted from close cooperation with Glenn Morin and Robin Spitko (NEFCON) who have been closely involved through membership on the national Tolerance Reassessment Advisory Committee (TRAC) and the National Alliance of Independent Crop Consultants.

In 1999, at the request of leading Massachusetts fruit growers, the Fruit Team designed two studies to generate data on mitigating uses of the key organophosphate (OP) insecticides azinphosmethyl and phosmet for submission to EPA. The studies were conducted at nine commercial fruit farms in Massachusetts and two in New Hampshire. Pesticide residue analyses were conducted by the Massachusetts Pesticide Analytical lab (MPAL) at UMass, Amherst. Studies were designed to show the effects on residues at harvest of restricting azinphosmethyl use only to the early season against plum curculio (Residue Decline Study), or of using various rates (full rate, half rate, one quarter rate) of azinphosmethyl or phosmet later in the season against apple maggot (Bridging Study). A residue-decline study seeks to establish a relationship between residue levels at the time of application and those detected over time, including at the pre-harvest interval specified on the label. A bridging study is intended to establish a relationship among residues from field trials conducted at the maximum application scenario (e.g., maximum application rate, highest application frequency, and shortest pre-harvest interval) and residues which occur from more typical applications.

Materials & Methods

Treatments. Seven orchards agreed to participate in the Azinphosmethyl Residue Decline Study (ARDS). Each test block consisted primarily of well-pruned, mature, semi-dwarf McIntosh trees. Applications were conducted by cooperating growers using their own calibrated sprayers and the 50WSP formulation, at per-acre rates ranging from 0.75 to 1.5 lbs. formulated product per acre (depending on tree row-volume). Timing and need for applications were determined by the grower, but no azinphosmethyl applications were planned after the last spray for plum curculio. Fungicides were applied by the grower on an as-needed basis and were not part of the residue analysis.

Three orchards agreed to participate in the Phosmet Bridging Study (PBS). Each test block consisted primarily of well-pruned mature McIntosh trees. With the understanding that one grower planned to switch from early-season azinphosmethyl use to later-season use of phosmet, in that case, the PBS was overlain on trees also sampled for the ARDS. In the other two orchards, phosmet was the insecticide primarily used throughout the season, so no ARDS was conducted. Pesticide applications were conducted by cooperating growers using their own calibrated sprayers and either the 70WP or 70WSB formulation, at per acre rates ranging from 0.8 to 3 lbs. formulated product per acre (depending on tree-row volume). Timing and need for applications were once again determined by the grower, and fungicides were applied as needed.

At the request of the growers, one orchard was the site of an Azinphosmethyl Bridging Study (ABS), using three rates of the 50 WSP formulation: 10 oz., 5 oz., and 2.5 oz. per 100 gallons, and a second was the site of an ABS using two rates of the 50 WSP formulation: 8 oz. and 4 oz. per 100 gallons. Cultivar mix and tree size in these two blocks were the same as other blocks described above. Timing and need for applications were once again determined by the grower, and fungicides were applied as needed.

Sample collection. At the study's onset, the authors met to discuss the protocol for collecting and storing samples. It was decided initially to collect composite samples of up to 20 fruit (depending on size) from each treatment block in collaborating orchards approximately monthly through the season. Fruit were collected by snipping the stem with a hand pruners (so as to not contaminate individual fruit by handling) and dropping the fruit into previously-labeled foil-lined Zip-Loc™ bags. Once fruit were collected, bags were placed immediately into a cooler with ice packs and returned to campus. After recording the specimens into a chain of custody form at the MPAL, samples were frozen and stored

Table 1. Sample dates and azinphosmethyl residues found on pooled samples of McIntosh apple. Also included are the dates of the last azinphosmethyl application. 1999 Azinphosmethyl Residue Decline Study.

Orchard	Date of last azinphos-methyl application	Sample collection dates (residues of azinphosmethyl in μg/g)				
A	May 27	6/23 (0.074)	7/27 (1 N.D.)[1]	8/23 (6 N.D.)	8/31 (6 N.D.)[2]	9/7 (7 N.D., 0.12, 0.11)
B	June 2	6/23 (0.307)	7/27 (0.05)	8/26 (3 N.D.)	9/1 (2 N.D., 0.12)[2]	No Sample
C	May 27	6/23 (0.167)	7/28 (1 N.D.)	8/23 (3 N.D.)[2]	No Sample	No Sample
D	May 30	6/24 (0.136)	7/27 (1 N.D.)	8/23 (3 N.D.)	9/1 (N.D.)[2]	No Sample
E	May 29	6/23 (0.13)	7/27 (1 N.D.)	8/23 (3 N.D.)	9/1 (3 N.D.)	9/7 (3 N.D.)[2]
F	May 28	6/23 (0.082)	7/28 (1 N.D.)	8/23 (3 N.D.)	9/1 (3 N.D.)[2]	No Sample
G	May 22	6/28 (0.106)	7/29 (0.05)	8/26 (3 N.D.)	9/2 (3 N.D.)[2]	No Sample

1. N.D.: no residues were detected on a specified number of pooled samples collected on that date.
2. Samples taken at the 14-day pre-harvest interval prior to estimated harvest date.

Table 2. Sample dates and phosmet residues found on pooled samples of McIntosh apple. Also included are the dates of the last phosmet application. 1999 Phosmet Bridging Study.

Orchard	Date of last phosmet application	Rate (oz./ 100 gal.)	Sample collection dates (residues of phosmet in μg/g)		
A	July 10	16	6/23 (1 N.D.)[1]	8/27 (2 N.D., 0.05)	9/7 (0.067)[2]
		8	6/23 (1 N.D.)	8/27 (3 N.D.)	9/7 (0.0933)
		4	6/23 (1 N.D.)	8/27 (3 N.D.)	9/7 (1 N.D., 0.08)
H	July 27	16	no sample	8/25 (0.139)	no sample
		8	no sample	8/25 (1 N.D., 0.07)	no sample
I	August 7	16	no sample	8/26 (1.807)	9/2 (1.123)
		8	no sample	8/26 (0.703)	9/2 (0.29)
		4	no sample	8/26 (0.303)	9/2 (0.223)

1. N.D: no residues were detected on a specified number of pooled samples collected on that date.
2. Harvest date.

appropriately until later analysis.

After the initial collection period (end of June) had been completed, the EPA published two relevant draft guidelines which resulted in a modification of the above protocol to comply more closely with EPA guidance. Specifically, we henceforth collected three composite samples from each treatment block on each sample date, with the last sample date corresponding to the pre-harvest interval (PHI) for the material. By the time the draft EPA guidance was published (7/29/99), it was impossible to comply with certain suggested aspects of the EPA protocol, including collection of a control sample prior to any application of pesticide or collec-

Table 3. Sample dates and azinphosmethyl residues found on pooled samples of McIntosh apple. Also included are the dates of the last azinphosmethyl application. 1999 Azinphosmethyl Bridging Study.

Orchard	Date of last azinphos-methyl application	Rates	Sample collection dates (residues of azinphosmethyl in µg/g)		
J	---	8 oz./100	8/24 (0.23)	8/31 (0.1133)[1]	no sample
		4 oz./100	8/24 (0.085)	8/31 (0.086)[1]	no sample
K	August 18	10 oz./100	8/24 (1.18)	8/26 (1.753)[1]	9/9 (0.483)
		5 oz./100	8/24 (1.09)	8/26 (0.527)[1]	9/9 (0.247)
		2.5 oz./100	no sample	8/26 (0.07)[1]	9/9 (0.063)

1. Samples taken at the 14-day pre-harvest interval prior to estimated harvest date.

tion of samples immediately after application.

Sample extraction and analysis. Azinphosmethyl and phosmet residues were analyzed as reported previously (S. Wright, et al., 1998, *Fruit Notes* 63(2):1-3). Residues were analyzed from extracted whole apples using gas chromatography with nitrogen-phosphorus and Mass-selective detection. Pesticide recoveries from organic apples fortified with azinphosmethyl and phosmet (0.05 Fg/g - 2.0 Fg/g, N=38) were 98.5 % ± 15 and 105 ± 16, respectively. Residues of azinphosmethyl and phosmet were never detected on any (N=38) of the laboratory control samples (organic apples).

Residue Decline Study Results and Discussion

Not surprisingly, residues of azinphosmethyl were detected on samples collected approximately one month after the last actual application in all seven treatment blocks (Table 1). However, largely in keeping with our original hypothesis, there were no detectable azinphosmethyl residues (limit of detection = 0.04 Fg/g) on any fruit collected 14 days prior to harvest in six out of seven sampled ARDS blocks. This result was consistent with a study conducted by Wright et al. in 1997 (*Fruit Notes* Vol. 63 (2):1-3, 1998.) where they found no detectable residues at harvest in five third-level IPM blocks which received no azinphosmethyl applications after June 30.

In one orchard, small amounts of azinphosmethyl were detected prior to harvest (0.12 and 0.11 Fg/g respectively), in two out of ten composite samples taken. This was in spite of the fact that no Azinphosmethyl was detected on samples taken on three previous dates in that block. We are unable to explain fully the presence of these residues, since the grower assures us that no azinphosmethyl had been applied to the block or anywhere else in the entire orchard after May 27. We suspect that results reflected the extremely dry summer experienced in Massachusetts in 1999. Presence of small residues in two out of nine pooled samples collected on 9/7 reaffirms the need for multiple samples in order to account for residue variation among individual fruits growing on different trees or at different positions on trees.

Bridging Study Results and Discussion

In the three orchards which participated in the phosmet bridging study, there appeared to be a trend toward correlation between rates applied and resultant residues (Table 2). In one PBS block, azinphosmethyl residues just above the analytical limit of detection (data not shown) were found at the PHI in trees which the grower reports had received no deliberate applications of that material. Based on the grower's spray records, we suspect that this may have been due to drift from adjacent blocks of trees that received a late season application of a low rate of azinphosmethyl against apple maggot fly.

In the two orchards which conducted the azinphosmethyl bridging study, there was a much better relationship between rates used and resultant residues (Table 3). The differences can not be explained conclusively, although variation in mixing/loading procedures, weather during application, or sprayer calibration likely contributed.

Conclusion

Based on these results, it appears that our original hypothesis (that restricting azinphosmethyl applications only to early-season pests) typically will result in no detectable residues at harvest. Such a potential strategy is essentially the same as increasing the PHI to 90 days, far more than the current requirement of 14 to 21 days (depending on rate of last application). Given the extremely low rainfall during the 1999 growing season, this test can be considered to be a "worst-case scenario," given that weathering by rainfall is a significant source of residue removal from fruit under more normal conditions. Results also point out the substantial variability of application outcomes from orchard to orchard. This variability likely results not only from use of different sprayers, travel speeds, rates of concentration (e.g., 3X, 6X, etc.), and frequency of calibration, but also from individual grower's mixing/loading and application style.

Regarding use of lower-than-maximum label rates, our data confirm that residues of azinphosmethyl at harvest, while affected by the date of last insecticide application, are also related to rate of formulated product used. Thus, using the lowest effective rates not only makes good economic sense, but also provides an additional margin of safety regarding potential residues at harvest. Such a low-dose strategy also can be a resistance-management tool given that pest resistance typically develops to the highest rate to which pests have been exposed.

Acknowledgments

We sincerely thank all cooperating growers: Gerard Bierne, Bill Broderick, Greg Gilmore, Rick Leadbeater, Jay Marshall, Andrew Martin, Bill Rose, Max Russell, Joe Sincuk, Mo Tougas, and Steve Wood. This study was paid for with contributions from some cooperating growers, and with funds from the Massachusetts Pesticide Impact Assessment Program, and the UMass Agroecology Tree Fruit Smith-Lever Extension budget.

* * * * *

Influence of Surfactants on the Performance of ReTain as a Harvest-management Tool on Marshall McIntosh Apples

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McIntosh is the most widely planted and most important apple variety grown in New England. Our unique set of environmental conditions allow McIntosh to be grown here better than almost anywhere in the world. One of the shortcomings of this variety is that it can, and usually does, display excessive preharvest drop. In an average year up to 25% of the fruit can be lost due to drop, while in severe years, where above average temperatures are experienced during the harvest season, over 50% of the fruit can fall before they can be harvested.

Various strategies have been employed to overcome some of the deficiencies of McIntosh. In the 1940's it was found that the chemical thinner naphthaleneacetic acid (NAA) could also retard preharvest drop. One application was effective for 7 to 10 days and a second application gave an additional 7 days of drop control. This compound is currently registered for controlling drop of apples. While it is sometimes effective at controlling drop, proper timing is important, ripening may be advanced, and the storage potential may be reduced. The discovery and ultimate registration of Alar for control of preharvest drop on apples was an enormous benefit to McIntosh growers in New England. However, the registration of Alar for use on apples was withdrawn in the late 1980's leaving growers only with the somewhat inadequate NAA for drop control.

Aminoethoxyvinylglycine (AVG) was developed as the ReTain formulation following the loss of Alar as a harvest-management compound on apples. In general, it has been a very effective compound. However, relative to other agrochemicals it is considered to be very expensive. Label directions for ReTain contain the suggestion that specific

Table 1. Effects of Retain, surfactants used with Retain, and NAA on quality of Marshall McIntosh apples.

Treatment	Red[1] color (%)	US Extra fancy (%)	Flesh firmness (lb)	Soluble solids (%)	Starch rating (1-8)
	Mean of harvest on 9/11, 9/18, 9/25 and 10/2				
Control	75 ab	78 a	14.9 c	12.0 a	5.0 b
Retain + Silwet (8/15)	72 b	74 ab	15.5 a	11.9 a	4.5 c
Retain - No surfactant (8/15)	72 b	67 b	15.3 ab	11.8 a	5.1 b
Retain + 0.1% Kinetic (8/15)	72 b	73 ab	15.4 ab	11.8 a	5.0 b
NAA 10 ppm (9/5)	77 a	81 a	15.0 bc	11.9 a	5.5 a
Significance					
Retain	*	*	**	NS	***
Harvest date	***	***	***	***	***
Retain x harvest date	**	**	NS	NS	*

[1]Means within columns not followed by the same letter are significantly different at odds of 19 to 1.

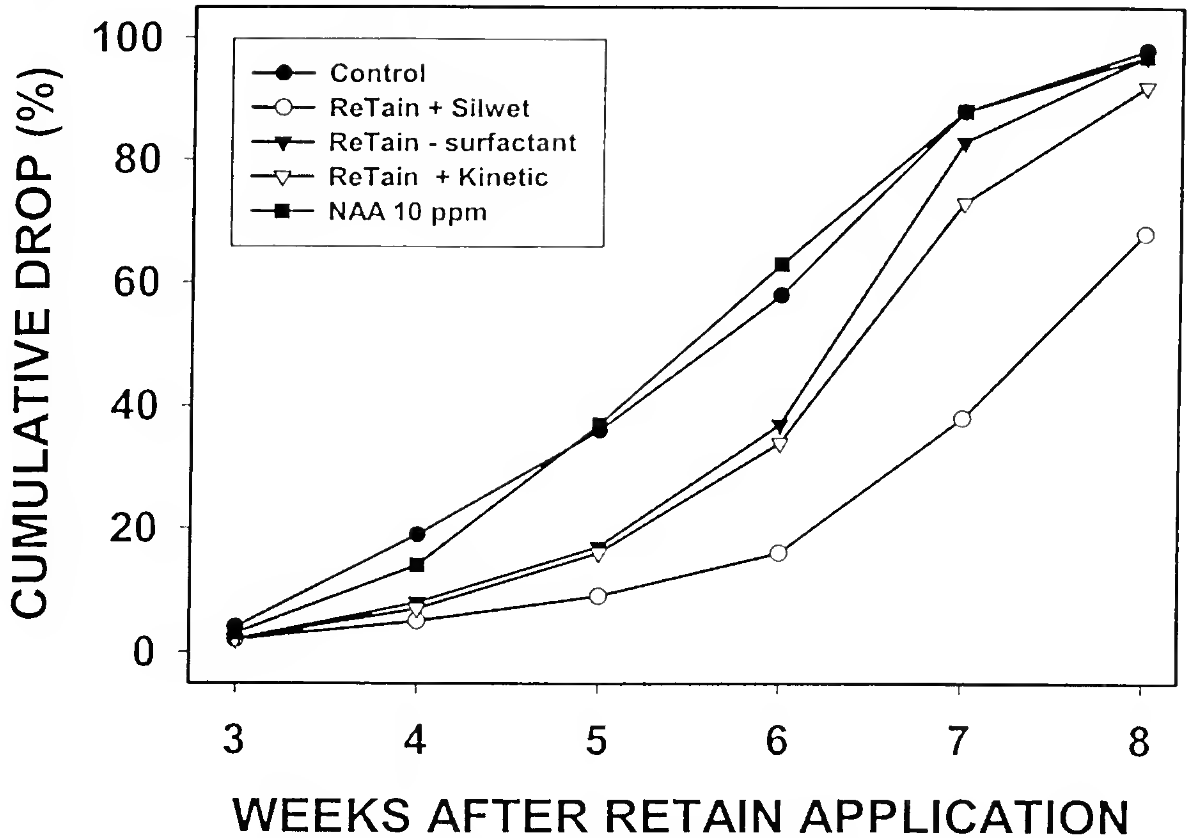

Figure 1. Cumulative drop of Marshall McIntosh apples treated with ReTain, ReTain with either Silwet or Kinetic organosilicate surfactants, and NAA.

surfactants should be used to enhance uptake and improve the performance of ReTain. The purpose of this communication is to confirm the importance of including a recommended surfactant when ReTain is applied as a preharvest-drop-control compound. Since NAA is the only other compound registered to control drop on apples, it was included to allow comparison with ReTain.

Materials & Methods

A block of mature Marshall McIntosh/Mark was selected at the University of Massachusetts Horticultural Research Center in Belchertown, MA. Sixty trees were blocked into six groups (replications) of 12 trees each based upon crop load and proximity. Trees in each replication were paired, with one tree in each pair being designated as a sample tree while the second tree was designated as a drop tree. On August 15, two trees in each block were sprayed with 90 ppm ReTain only, ReTain with 0.1% Silwet, or ReTain with 0.1% Kinetic, respectively, at a dilute gallonage of 125 gallons per acre. One pair of trees in each block received a 10 ppm spray of NAA on September 5, and the last pair of trees in each replication received no spray and served as a control. Twenty five fruit were harvested from the perimeter of each sample on September 11, 18, 25, and October 2. The percent of the surface with red color was estimated to the nearest 10% as well as determining if the red color was intense enough to meet US Extra Fancy red color standards. A subsample of 10 fruit , representative of the sample was selected and flesh firmness determined on two sides of each fruit using an Effegi penetrometer. Fruit soluble solids were determined on a composite sample of juice collected while doing the flesh firmness, using a hand refractometer. Fruit from the firmness test were cut in half, dipped in a starch-iodine solution, and the starch pattern then rated using the Cornell generic starch chart. On August 29, all fruit were picked up under drop-designated trees and discarded. Twice weekly all fruit under drop trees were picked up and counted. On October 20, all fruit remaining on the drop trees were harvested and counted and the cumulative drop calculated.

Results

In general, ReTain affected fruit quality at harvest predictably (Table 1). ReTain retarded red color development but this reduction in red color was not sufficiently great to consistently reduce the number of fruit classified as US Extra Fancy. All ReTain treatments retarded the loss of flesh firmness. No treatment influlenced fruit soluble solids. Fruit maturity, as determined by starch index, was retarded only when Silwet was included with the ReTain. NAA advanced fruit maturity but otherwise had little influence on other fruit quality.

ReTain had little influence on red color development on the first two harvests but at the later harvests red color development was delayed (data not shown). Conversely, ReTain retarded starch degradation at the early harvest dates, but at later harvests the differences were less.

All ReTain treatments retarded preharvest drop on Marshall McIntosh (Figure 1). However, during the last week in September, the ReTain treatments containing Kinetic or having no surfactant became clearly less effective at controlling preharvest drop than the ReTain treatment containing Silwet. The ReTain treatment containing Silwet continued to be better than the other two ReTain treatments for the duration of the experiment. NAA in general was ineffective as a preharvest drop compound. Only once, on September 15 (10 days after application), did NAA significantly retard drop, and the reduction at this time was only 4% better than the untreated control.

Discussion

The commercial harvest window of the fruit based upon starch-iodine index was from mid to late-September (4.5 to 6 weeks after ReTain application). Application of ReTain following label directions using 0.1% Silwet, a recommended surfactant, effectively controlled preharvest drop. Drop control of ReTain-treated fruit without a surfactant or when applied with Kinetic was not as effective as when Silwet was used. However, the differences in drop control between these two treatments did not become apparent until after most of the harvest would have been completed (5 weeks after ReTain application).

Currently, there are four surfactants recommended for use with ReTain: Silgard 309, Silwet L-77, Break-Thru, and RNA Si 100. The latter two are only available through suppliers located on the west coast. We suggest using only the recommended surfactants, thus for growers on the east coast the choice is limited to either Silwet L-77 or Silgard 309.

ReTain had a small but significant effect on red color development. We do not look at this as a reduction in red color development *per se*, but rather a delay in development that is associated with consequence of delayed ripening. Fruit would have had similar if not greater red color if one compared red color on fruit of a comparable starch rating.

NAA has been registered as a stop-drop compound for many years. However, its use on McIntosh is not widespread. Many years it is not effective or at best it is marginally effective. In this investigation NAA had little effect on drop control. Unless it can be made to work more consistently, its use on McIntosh is likely to be very limited. NAA can advance ripening especially if warm weather follows application. In this investigation weather was seasonable, so advanced ripening effects were limited to a small increase in the starch index.

* * * * *

Effects of Simulated Rain Following ReTain Application on Preharvest Drop and Fruit Quality of McIntosh Apples

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All who manage orchards have experienced the indecision associated with having a weather forecast suggesting the possibility of a 30 to 50% possibility of thundershowers on a day when you would like to spray. It would help the decision-making process to know what the repercussions would be if heavy rain followed the application of a very important spray application. The purpose of this study was to evaluate the effects that a simulated heavy thundershower would have on preharvest drop and fruit quality following a ReTain application.

Materials & Methods

1992 Study. A block of 5-year-old Marshall McIntosh/Mark was selected at the University of Massachusetts Horticulture Research Center, Belchertown, MA. Sixty trees were selected and blocked into six groups (replications) of ten trees each based upon crop load and proximity. Trees in each block were paired, with one tree in each pair being designated as a sample tree, while the second tree was designated as a drop tree. On August 24, 1992, ten of the twelve trees in each replication received a dilute spray of 225 ppm AVG applied with a hand-gun, sprayed to drip. One hour after application, two trees that were previously sprayed with AVG were washed with 6 to 7 gallons of water using a hydraulic sprayer with a hand gun attached. Pairs of AVG-treated trees were similarly washed at 4 and 8 hours after application. Two trees in each block were not sprayed with AVG and served as the untreated control trees. On September 17, fifteen fruit were randomly harvested from the periphery of each of 30 trees designated as the sample trees. Fruit were weighed, and then the percent red color was estimated visually to the nearest 10%. Flesh firmness was measured using an Effegi penetrometer with two punctures per fruit. A composite juice sample collected during the pressure test was used to determine soluble solids using a hand-held refractometer. Fruit were then cut in half, dipped in starch iodine solution, and maturity then estimated using the McIntosh starch chart

Table 1. Effects of AVG and time of simulated rain (washoff) on fruit quality at harvest of Marshall McIntosh/Mark. 1992.

Treatment[1] (ppm)	Washoff time	Flesh firmness (lb)	Soluble solids (%)	Red color (%)	Starch[2] rating
Control	---	14.6 b	12.8 a	91 a	5.0 a
AVG 225	none	15.2 a	12.3 b	83 c	4.6 b
AVG 225	1 hr	15.0 ab	12.8 a	86 b	4.7 b
AVG 225	4 hr	14.7 b	12.7 a	87 b	4.6 b
AVG 225	8 hr	14.9 ab	12.8 a	89 b	4.7 b
Significance					
AVG		*	*	***	*
Harvest date(HD)		***	***	***	***
AVG x HD		NS	NS	**	NS
Washoff		NS	NS	NS	NS
AVG vs. Control		**	***	***	***
AVG vs. Washoff		NS	***	**	NS

[1]AVG applied August 24, 1992.
[2]Starch rating 1-3, immature; 4-6, mature; and 7-9, overmature.
Means within columns not followed by the same letter are significantly different at odds of 19 to 1.

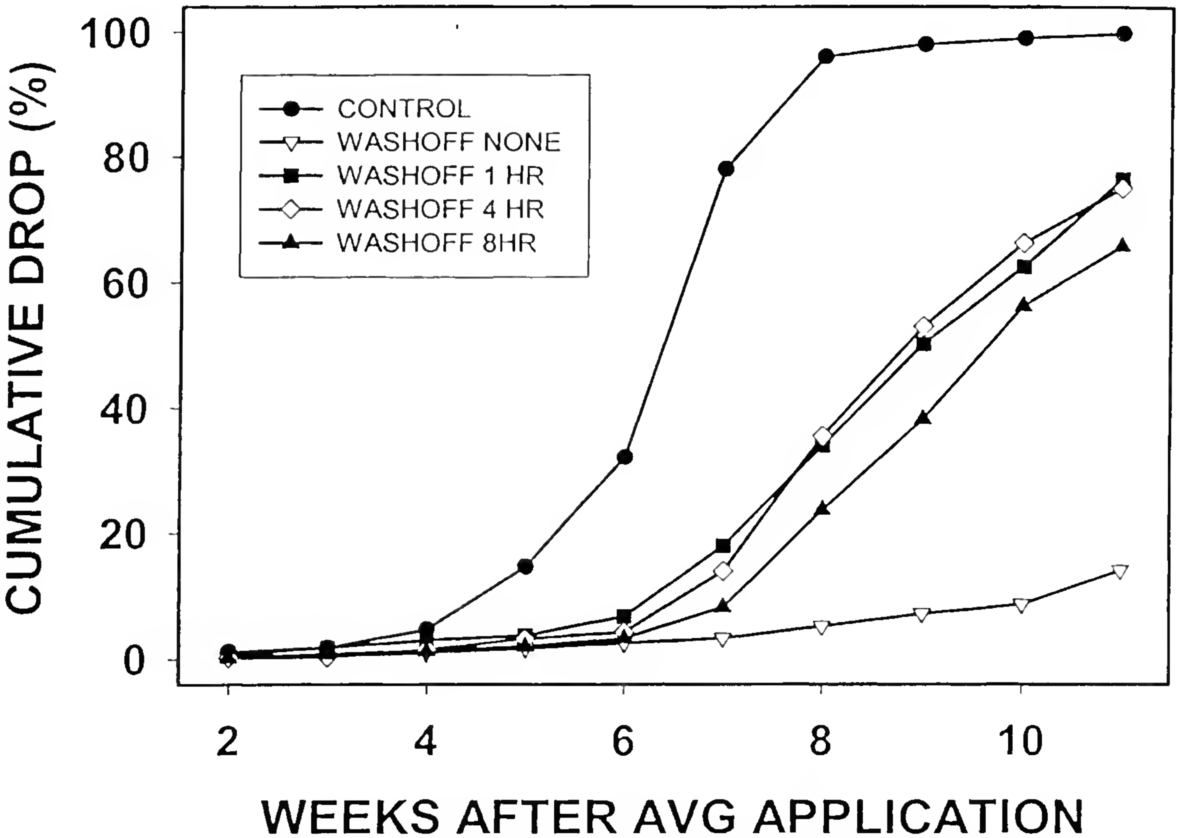

Figure 1. Effects of AVG and the and simulation of rain on AVG-treated trees on cumulative drop of Marshall McIntosh/Mark apples. 1992.

developed by Priest and Lougheed. Three additional harvests were made and fruit were similarly evaluated at weekly intervals on September 24, October 1, and October 8. All fruit were picked up under each tree designated as a drop tree on September 1 and then twice weekly until November 9. On each drop-pick-up day the number of fruit picked up under each tree was recorded. On November 9, all fruit remaining on the drop trees were harvested and counted. Cumulative drop per tree was then calculated.

2000 Study. A block of mature Marshall McIntosh/M.26 was selected at the University of Massachusetts, Horticultural Research Center, Belchertown, MA. Sixty trees were selected and blocked into six groups (replications) of 12 trees each based upon crop load and proximity. On August 17, ten of the twelve trees in each replication were sprayed with 50 g a.i./acre ReTain containing 0.1 % Silwet in 100 gallons per acre using a rear-mounted airblast sprayer. TRV assessment suggested that these trees would require 140 gallons per acre for a dilute application. One hour after ReTain application, two trees in each block that had received ReTain were washed with 10 to 12 gal of water for 3 to 4 minutes using an hydraulic sprayer with a hand gun attached. Particular effort was made to direct the wash water on the fruit and spur leaves. Pairs of ReTain-treated trees were similarly washed at 3 hours and 8 hours after application. Two trees in each block did not receive ReTain and served as the untreated control trees. On September 7, twenty fruit were harvested randomly from the periphery of each of the 30 trees designated as the sample trees. Fruit were weighed, and then the percent of the fruit surface that was red was estimated visually to the nearest 10%. Further, the red color was judged to determine if it was intense enough to meet US Extra Fancy standards. A representative 10-apple subsample was taken and flesh firmness and soluble solids determined as described in the 1992 investigation. Fruit were then cut in half, dipped in starch iodine solution, and maturity then estimated using the generic starch chart developed at Cornell University. Three additional harvests were made, and fruit were evaluated similarly at weekly intervals on September 14, September 21, and September 28. All dropped fruit were picked up under each tree designated as a drop tree on September 1 and then twice weekly until October 16. On each drop pick-up day the fruit picked up under each tree were recorded. On

Table 2. Effects of AVG (ReTain) and time of simulated rain (washoff) on fruit quality at harvest of Marshall McIntosh/M.26. 2000.

Treatment[1]	Washoff time	Flesh firmness (lb)	Soluble solids (%)	Red color (%)	US Extra fancy (%)	Starch[2] rating
Mean of Harvests on 9/7, 9/14, 9/21, and 9/28						
Control	—	15.2 c	11.3 ab	72 a	70 a	5.7 a
AVG 50 gai	1 Hr.	15.8 ab	11.2 bc	69 ab	68 a	5.4 a
AVG 50 gai	3 Hr.	15.6 bc	10.9 c	70 ab	64 ab	5.4 a
AVG 50 gai	8 Hr.	16.1 a	11.6 a	67 b	61 ab	5.2 a
AVG 50 gai	None	15.7 ab	11.2 bc	66 b	53 b	5.2 a
Significance						
AVG		**	NS	*	***	*
Harvest date (HD)		***	***	***	***	***
AVG x (HD)		NS	NS	NS	NS	NS
AVG vs. Control		***	NS	**	NS	NS
AVG vs. Washoff		NS	NS	NS	NS	*

[1]AVG at 50 gai/acre was applied August 17, 2000 in 100 gal of spray containing 0.1% Silwet on 140 gal/acre TRV trees.
[2]Starch rating 1-3, immature; 4-6, mature; 7-8, overmature.
Means within columns not followed by the same letter are significantly different at odds of 19 to 1.

October 16, all fruit remaining on the drop trees were harvested and counted. Cumulative drop per tree was then calculated.

Results

AVG applied in 1992 significantly increased flesh firmness, and reduced soluble solids, red color development, and starch iodine rating (Table 1). Simulated rain following application modified the AVG effect. Soluble solids were restored to the levels of the control fruit and red color retardation was reduced, whereas flesh firmness and starch rating were not affected. AVG resulted in a greater reduction in red color development at the early harvest than at the later harvests (data not shown).

All AVG treatments applied in 1992 significantly and comparably retarded preharvest drop for the first 6 weeks after application (Figure 1). At 7 weeks after application and later, the effectiveness of AVG was significantly diminished on trees that were washed to simulate a soaking rain.

AVG applied in 2000 significantly increased fruit flesh firmness, while reducing red color, the percent of fruit that were judged to meet the US Extra Fancy grade, and starch rating (Table 2). The only effect simulated rain had on fruit quality parameters was that the percent of fruit in the US Extra Fancy category was slightly lowered when trees were washed one hour after ReTain application. As expected, the major AVG effect was a reduction in red color and an increase in fruit flesh firmness.

AVG significantly retarded preharvest drop compared with the control (Figure 2). This response was evident on the first date dropped fruit were collected, and it extended through the entire drop-evaluation period. Simulated rain did not reduce the effects of ReTain on preharvest drop, since at no time during the drop pickup period did any washed trees that received ReTain have more dropped fruit under them (percent of total) than unwashed trees that also received ReTain.

Discussion

The purpose of these experiments was to determine if the performance of ReTain would be altered by subjecting trees to simulated rain at intervals after application. The conditions of application and the contents of the spray used were quite different in the two years. The experiment done in 1992 used AVG technical powder formulated for testing AVG. It was applied to the drip point with a hand gun, and no surfactant was used. The experiment done in 2000 mimicked a commercial application of AVG as the commercial ReTain formulation was used, it was applied according to label directions, and the application was made using a commercial airblast sprayer. Further, the spray contained 0.1% Silwet surfactant, a label-recommended surfactant, at a recommended concentration. Clearly, there were differences in response to the simulated rain in the two years. In 1992, washing trees, even as much as 8 hours after

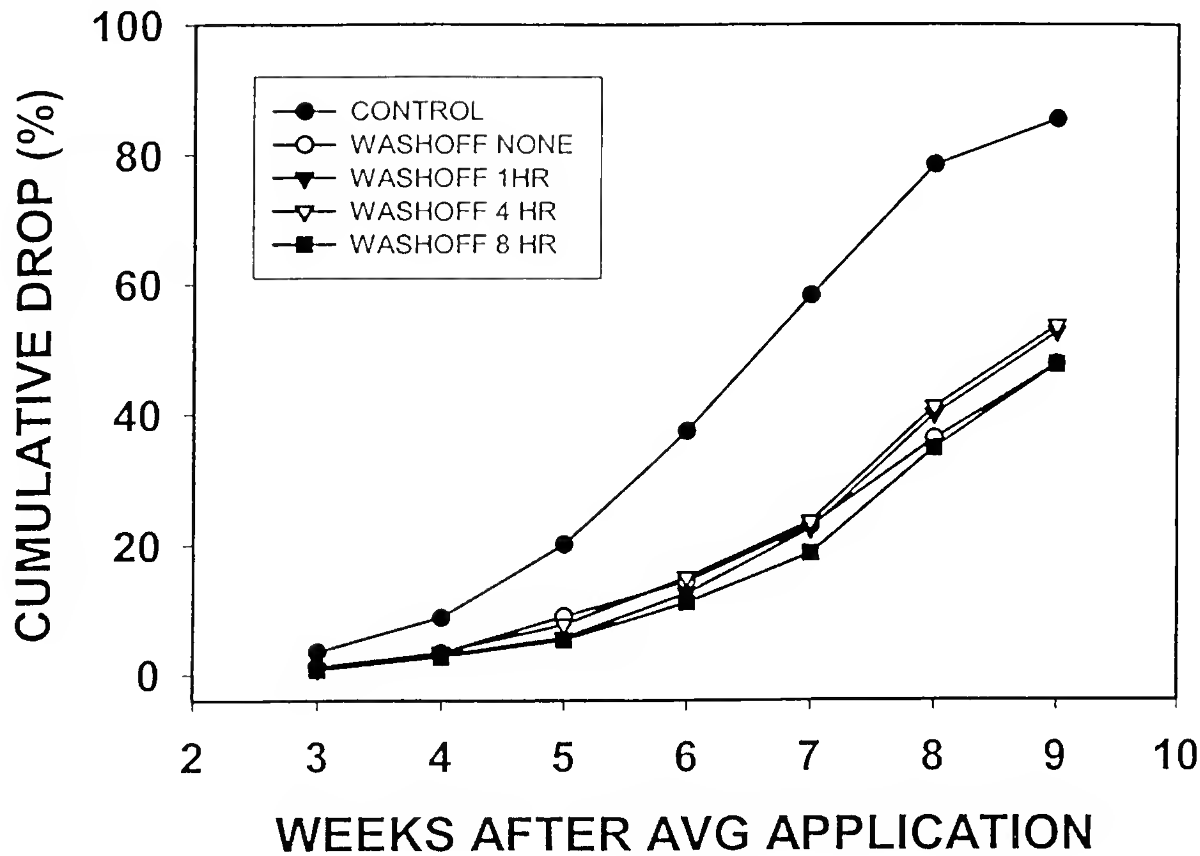

Figure 2. Effects of AVG as the ReTain formulation and simulated rain on ReTain-treated trees on cumulative drop of Marshall McIntosh/M.26 apples. 2000.

application resulted in reduced drop control and a modification of the reduction in red color and lowering of soluble solids normally associated with ReTain use. In 2000, washing trees even as soon as 1 hour after application resulted in no reduction in drop control and a minimal effect on the intensity of red color as indicated by a small reduction in the number of fruit that were judged to be US Extra Fancy. Different formulations of AVG were used in the two years may have been a contributing factor. However, we believe that the major factor responsible for the extreme rainfastness demonstrated in 2000 was the use of Silwet. There are a number of citations in the literature that demonstrate that the use of Silwet with other agricultural chemicals imparts rainfastness.

In a previous report we emphasized that the use of a recommended surfactant was important to achieve the maximum response from ReTain. The results from this investigation provide another convincing reason to use a recommended surfactant when applying ReTain.

Based upon previous experience, the window of opportunity to apply ReTain is reasonably wide. However, weather during August can be quite fickle and very unpredictable. It appears that the use of Silwet or possibly Sylgard 309 with ReTain provides a certain amount of insurance that if rain or a shower follows soon after application, one can expect nearly 100% response to ReTain.

The commercial application of ReTain in 2000 confirmed that ReTain is an effective drop-control compound and harvest-management tool. It effectively retarded preharvest drop for at least 7 weeks after application, into early October, and significantly retarded it well beyond that time. Further, it retarded the loss of flesh firmness and delayed ripening, which would allow scheduling of harvest or extending the harvest season in a pick-your-own operation.

* * * * *

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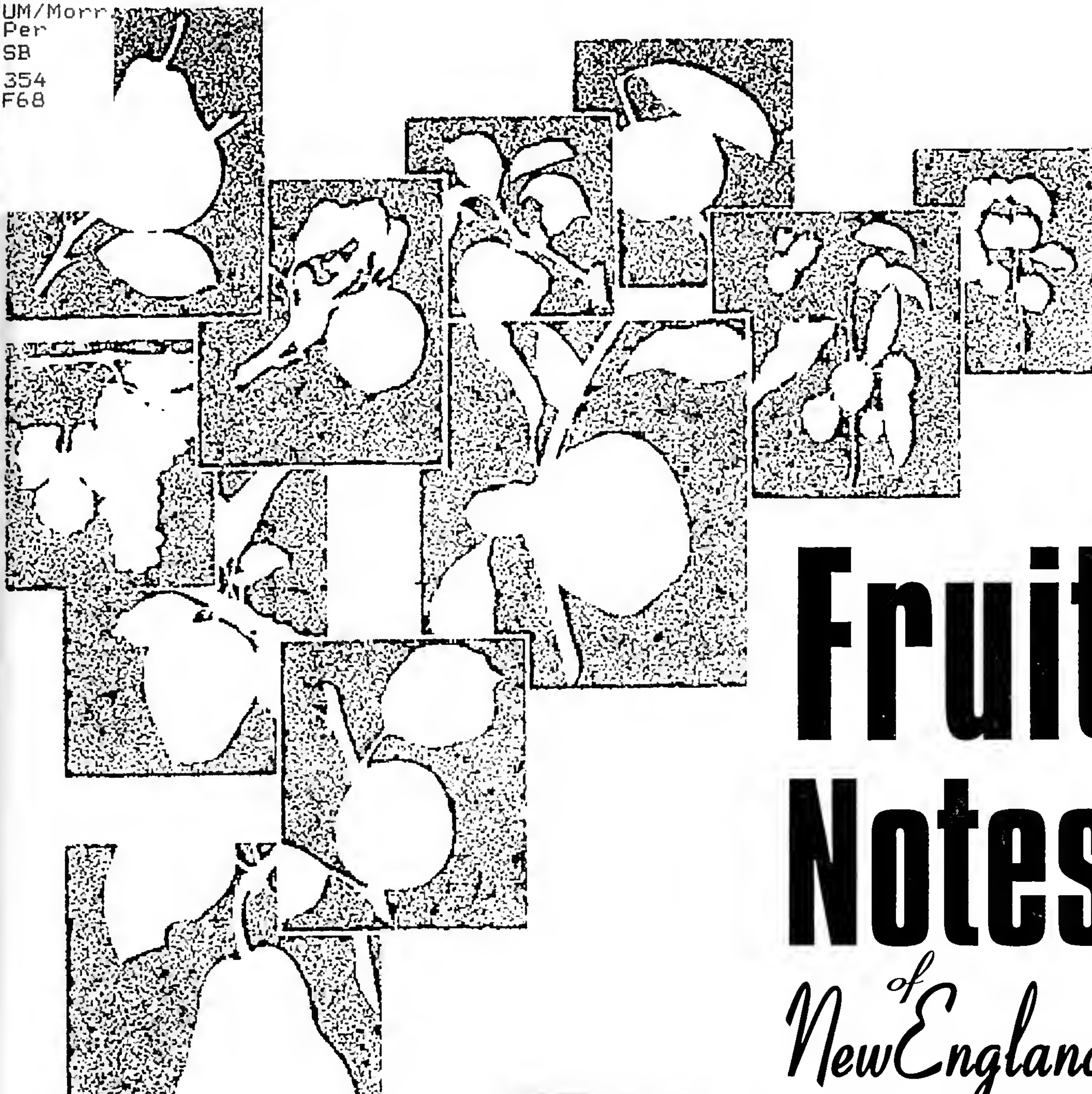

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On the Origin of the Edible Apple

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It is generally believed that the edible apple originated somewhere in Central Asia. It is a member of the *Rosaceae* (rose) Family, and is designated by the scientific name *Malus domestica*. There are many other wild species of Malus, and it is generally assumed that *M. domestica* evolved from chance hybridization among these wild species.

A recent article in *The Garden*, a publication of the Royal Horticultural Society, London, England (Volume 126 (6), June, 2001) paints an interesting new picture of the apple's origin. Over the past four years Dr. Barrie Juniper, Emeritus Fellow in the Department of Plant Sciences at Oxford University, has been pursuing this question using the new power of DNA analysis. He believes that the hybridization theory is almost certainly false and that the true origin of the apples we eat today is a small population of a single species still growing in the Ili Valley on the northern slopes of the Tien Shan ("Heavenly Mountains") mountains at the border of northeast China and the former Soviet Republic of Kazakhstan. (The name of Kazkhstan's capital, Almaty, means "father of apples.") He believes that this isolated species has evolved over the past 4.5 million years to become larger and sweeter, and was carried into the Western World by travelers on the ancient "silk roads."

In 1997, Dr. Juniper and a small research group discovered a "malian wonderland" of wild fruit trees in Kazakhstan at an altitude of 5,000 feet on a mountainside overlooking China. The apple trees there grow 30 feet in height and bear fruits ranging in color from yellow to red, and in size from that of crabapples to that of large, commercial cultivars. Leaves were taken from each tree and later analyzed for DNA composition. This showed them all to belong to the species *M. sieversii*, but with some genetic sequences common to *M. domestica*. Subsequent travels to the site and further research have created the following hypothesis on the evolution of today's edible apple.

Dr. Juniper believes that the original *Malus* species evolved in cental and southern China ten to twenty million years ago and bore a small fruit with hard but edible seeds. It was spread by birds throughout the northern hemisphere. A key small group of wild apples spread northwest from their central China origin during the time the Tien Shan mountain range was rising from the collision of the Indian and Asian land plates. Birds carried seeds into today's Kazakhstan. As the mountains created the Gobi and Taklimakan deserts to their east, these prevented seed transport back to the east. The result was that a population of *Malus* became isolated geographically among the towering Tien Shan mountains and slowly evolved in seclusion for geological periods of time.

As early as seven million years ago, this area was populated by forest deer, wild pigs, and bears in the woodlands, and by wild horses and donkeys on the Steppes further west. All of these herbivores would have gorged themselves on the apple fruits, selecting those trees producing larger, sweeter, and juicier fruit. They therefore selectively spread seeds from better tasting fruit aiding the evolution of these features. Selected in this way, gradually the apple changed from a bird's food with edible seeds to a larger mammal's food with poisonous (cyanide-containing) seeds. The seed coat became smooth, black, and hard, and the seed itself became tear-shaped, allowing it to pass easily through the animals' guts.

Much later, after the end of the last ice age (about 10,000 years ago), humans began to travel the animal migratory routes east and west (the "silk roads") and they too began consuming these new fruits, and began carrying them westward. The trees began to be cultivated in progressively more sophisticated ways in Mesopotamia and then in the Mediterranean area. The early trees all would have been grown from seeds, thus

producing a diverse population similar to that Dr. Juniper discovered in Kazakhstan. When the art of grafting was discovered and developed, clones of select types were capable of being cultivated and deliberate selections to be made. This process continues today.

Whether or not his hypothesis on the origin of apples is correct is debatable, but Dr. Juniper has opened the door to interesting new thinking about evolution of today's fruits. He himself is returning to the ancient fruit forest he discovered to repeat his apple studies on the pears, apricots, plums, and cherries also growing there. "We've started with the apple. Hopefully, we will go on to establish the genetic history of other fruits, too," says Dr. Juniper.

* * * * *

Twenty Years of Apple Production Under an Ecological Approach to Pest Management

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Since 1978, many apple growers in Massachusetts have been practicing what might be termed a "top down" approach to integrated pest management (IPM). This approach takes as its starting point a conventionally managed orchard that has been under commercial operation for several years or decades and aims, in stepwise fashion, at reducing the amount of pesticide used while gradually advancing the influence of natural ecological processes that promote buildup of natural enemies of pests. Over the past 20 years or so, numerous articles in *Fruit Notes* have reported on progress toward "top-down" IPM in commercial orchards.

An alternative approach to apple IPM that might be termed a "bottom-up" approach takes as its starting point a newly planted orchard and aims, in stepwise fashion, to add external inputs such as pesticide only as needed to augment natural ecological processes in overcoming biological barriers to attaining a high-quality marketable crop.

Since the 1970's, there has been an increasingly intensive effort on most continents where apples are grown to implement a top-down approach to integrated management of apple pests. In its initial stage, this effort usually has involved monitoring weather and/or pest abundance in an orchard and using information from monitoring, in conjunction with threshold values and models, for making decisions as to whether or not to apply a pesticide. Integration at this stage usually has taken the form of overt consideration of natural enemies of the pest in question and explicit attention to choosing pesticides that minimize harm to these and other beneficials. In more advanced stages, top-down approaches to apple IPM have increasingly emphasized integration across disciplines of entomology, pathology, weed science and horticulture and substitution of cultural, biological, genetic and behavioral methods of controlling apple pests for pesticidal methods.

More recently, a bottom-up approach to apple IPM has begun to receive attention. In its purest form, this approach is perhaps best expressed within the philosophy and practices of organic apple production. In a modified form, it may be expressed as ecological apple production that accents, prior to planting orchard trees, ecosystem design, habitat manipulation, cultural management, plant resistance to pests, and biological pest control through natural enemies as the foundational elements of IPM.

In 1977, I planted a small orchard of apple trees in Conway, Massachusetts specifically designed for commercial production using a bottom-up ecological approach to pest management. This approach has been maintained throughout all 20 years (1981-2000) of harvest and sale of fruit. I report here on pest management practices and pest incidence across the entire two decades of commercial sales. Long-term studies can be highly rewarding in elucidating the dynamics of pest populations comprising biological communities. Toward this end, a principal objective of this report is to portray long-term consequences of the ecologically-based pest management approach used in the Conway orchard.

Material & Methods

Orchard and Habitat Design

The orchard (about 1/3 acre) consists of 50 apple trees, all on dwarf (M.26) or semidwarf (M.7) rootstock. Woods border the orchard on the north and east, beginning 6 yards from perimeter apple trees. Open field stretching for 100 yards borders the orchard

on the south and west. Ten unmanaged apple trees, some annually bearing fruit, stand 200-250 yards from the orchard. Insofar as possible, the orchard was designed from the outset to maximize genetic-based host plant resistance to pests, minimize influx of pests arising from habitats bordering the orchard, and maximize influx of natural enemies of pests from bordering habitats. Annually, the orchard was pruned in March and received lime and fertilizer based on annual soil pH and leaf nutrient analysis.

The only key apple pest in Massachusetts which can be managed effectively solely through host plant resistance is the fungus that causes apple scab. All 50 trees were scab-resistant cultivars: 'Liberty' (35), 'Prima' (5), 'Priscilla' (5), and 'Freeedom' (5). All four cultivars also were sufficiently tolerant of three other pathogens to obscure, over the entire study, any symptoms of disease caused by them: the fungus that causes powdery mildew, the bacterium that causes fire blight, and the fungus that causes cedar apple rust. The only exception was moderate susceptibility of Prima to cedar apple rust.

Most important arthropod pests of apple orchards in Massachusetts are capable of dispersing into orchards from distances of several hundreds of yards, either by flight or passive wind-aided dispersal. However, the majority of females of one key insect pest, codling moth, was known from earlier work in Switzerland to move less than 100 yards within a single generation. Therefore, all unmanaged principal host trees of codling moth (apple, pear, hawthorn and quince) within 200 yards of the orchard perimeter were removed in 1980 to create a host-free zone sufficiently broad to discourage immigration of codling moth females. It was also hoped that such host removal might discourage immigration of lesser appleworm, which is closely related to codling moth, and several species of leafrollers.

Beneficial parasitoids and predators of several different apple orchard pests can provide effective biological pest control when allowed or encouraged to build on plants in habitats bordering orchards or on understory plants within orchards before moving into apple trees. Consequently, a decision was made to encourage the proliferation and growth of rosaceous plants (except the above) adjacent to the orchard. The supposition was that plants in the same family as apple (Rosaceae) would be the most likely to support non-pest species of arthropods that foster buildup of natural enemies of apple pests, particularly of foliar pests such as mites, leafminers, leafhoppers and aphids. No attempt was made to manage orchard understory plants in a way conducive to buildup of beneficial arthropods. Beginning with the first fruit-bearing year (1981), the orchard annually received a variety of practices designed to minimize the impact of pests in as ecologically sensitive a manner as practical.

Arthropod management

Several arthropod pests, active early in the growing season and for which no alternative management approaches were known or feasible, were managed through application of pesticide. This was accomplished by spraying orchard trees using a shoulder-mounted, motor-driven mist blower. Horticultural oil was applied annually throughout the 20 years at the tight cluster stage of bud development against overwintering nymphs of San Jose scale and overwintering eggs of European red mite. Phosmet was applied annually throughout the 20 years at or shortly after petal fall and again 10-17 days later, primarily against plum curculio and European apple sawfly. Phosmet was chosen because it afforded a better combination of effectiveness against plum curculio and relative safety to humans and beneficial predators of apple pests than any other insecticide available in 1981. These two annual applications of phosmet also were intended to suppress larvae of green fruitworm and first-generation adults, eggs and/or larvae of codling moth, lesser appleworm and leafrollers arising from immigrants unaffected by removal of unmanaged apple, pear, hawthorn and quince trees within 200 yards of the orchard.

Apple maggot flies were managed behaviorally by capturing females on unbaited red spheres, 3 inches in diameter and coated with Tangletrap™. They were deployed each year for 20 years at the rate of 1-3 per tree (according to fruit load) from early July through harvest. Insects and debris were removed from spheres twice (at monthly intervals) until harvest.

In an attempt to minimize within-orchard buildup of codling moth, lesser appleworm and apple maggot (all of which feed as juveniles inside of fruit), fallen apples (drops) were picked up weekly from early or mid-August until harvest and taken to a distant part of the farm.

Other than the pre-bloom spray of oil against

European red mite eggs, no action was taken against foliar pests such as mites, leafminers, leafhoppers or aphids. Instead, I relied on influx of beneficial natural enemies and their buildup in the absence of insecticide after the second application of phosmet in late May or early June. I did not, however, systematically sample abundance of beneficial natural enemies in or around the orchard to gather evidence that beneficials were in fact providing effective suppression of pest anthropods.

Disease management

As indicated above, cultivar resistance to or tolerance of pathogens was the principal approach used in managing apple diseases. This proved insufficient, however, for management of sooty blotch and flyspeck. Symptoms of these diseases do not permanently scar or deface fruit. Instead, symptoms appear as dark blotches or spots on the fruit surface, especially toward harvest. During the first quartile of orchard operation (1981-85), neither was sufficiently abundant to suggest that it should be managed. During the second quartile (1986-90), blotches and spots arising from these diseases became increasingly noticeable and were removed by cleaning each apple with a damp cloth before packing it for sale. This eventually proved so laborious as to be uneconomical. Therefore, during the third quartile (1991-95), certain hosts on which the causal pathogens overwintered, especially blackberry, grape and sumac, were removed if within 100 yards of the orchard in an effort to reduce influx of inoculum. Also, the orchard trees were pruned during summer to reduce relative humidity and hence inoculum establishment within the tree canopy. These measures proved partially but incompletely successful. Hence, during the fourth quartile (1996-2000), a combination of the fungicides captan and benomyl was applied twice annually (July and August) to suppress sooty blotch and flyspeck.

Weed management

During the first quartile, the orchard floor was mowed 5-6 times each year to enhance air flow, reduce competition of weeds for nutrients and water, and reduce vegetation favorable for establishment of voles. During the second quartile, hay as mulch was spread annually beneath the canopy of each tree to suppress weeds, conserve moisture and provide nutrients. Even though remaining mulch was removed in late August to discourage establishment of voles, eventually voles that fed on tree bark and roots became established in damaging numbers. Hence, during the third and fourth quartiles, mulching was no longer practiced, and I returned to the mowing regime of the first quartile.

Vertebrate pest management

Beginning in 1981, voles were managed by placing a roofing shingle beneath each orchard tree after harvest and placing poison bait (as needed) in trails beneath shingles.

Beginning in 1985, deer were repelled from feeding on developing twigs and buds by hanging a bar of scented soap on the trees at greatest risk.

Beginning in 1989, flocking birds (especially crows, bluejays and starlings) were repelled from alighting on trees and pecking fruit by suspending Scare-Eye balloons™about 2 yards above the uppermost foliage at 16-yard intervals. Balloons were employed annually in mid-August and remained through harvest.

Fruit thinning

As yields of fruit increased, it became uneconomical to rely solely on thinning of fruit by hand for ensuring acceptable fruit size. Hence, beginning in 1991, carbaryl was included as a chemical thinner with the first application of phosmet.

Sampling pest incidence

At harvest, a minimum of 25 randomly selected fruit on each of the 50 trees in the Conway orchard and on each of four unmanaged apple trees 200-250 yards away from the Conway orchard was sampled for pest injury. A fruit was classified as injured by a pest if the degree of injury was sufficient to preclude inclusion of the fruit for sale as "U.S. Fancy" grade.

Foliar populations of spider mites, leafminers, leafhoppers and aphids in the Conway orchard were assessed annually on a presence/absence basis at 3-week intervals from June to harvest by examining 10 leaves or 10 terminal shoots on each of 10 randomly-selected trees.

Results

The annual incidence of each fruit and foliar pest in the Conway orchard across the 20 years of orchard operation is depicted in Figures 1 and 2 in the form of regression lines that express pest incidence as a function of time. If a line shows an upward slope from 1981-2000, it means there was a positive relation between pest incidence and time. That is, the pest tended to increase in incidence over time. If a line shows a downward slope from 1981-2000, it means there was a negative relation between pest incidence and time. That is, the pest tended to decrease in incidence over time.

Among insect pests of fruit in the Conway orchard, only lesser appleworm showed a tendency to increase in incidence from 1981-2000, but the increase was slight and not significantly different from zero. All other insect pests of fruit, including tarnished plant bug, European apple sawfly, plum curculio, green fruitworm, codling moth, leafrollers and apple maggot showed a tendency to remain about the same or decrease in incidence from 1981-2000. Decreases were significantly different from zero only in the cases of tarnished plant bug and green fruitworm. There was no incidence whatsoever of San Jose scale during the entire 20 years.

Among disease pests of fruit in the Conway orchard, both sooty blotch and flyspeck showed a significant tendency to decrease in incidence from 1986-1990 (when incidence of these diseases was first sampled and when no management measures were used) to 1991-1995 (when three types of wild hosts within 100 yards of the orchard were removed) and thence to 1996-2000 (when two summer fungicide sprays were applied annually). There was no incidence of apple scab during any of these years.

Injury by birds in the Conway orchard showed a significant tendency to decrease from 1986-1988 (when no balloons were used as repellents) to 1989-2000, when balloons were employed throughout (data not shown).

Among arthropod pests of foliage in the Conway orchard, three pests (mites, woolly apple aphids and leafminers) showed a tendency to increase in incidence from 1986 (when first sampled) to 2000, but the increase was significantly different from zero only in the case of leafminers. White apple leafhoppers showed a tendency to decrease (but not significantly) from 1986-2000. In no year did populations of any foliar pest exceed levels considered potentially injurious.

Compared with annual pest incidence (across the two decades) on fruit of unmanaged trees 200-250 m from the Conway orchard, annual pest incidence on Conway orchard fruit (across the two decades) was significantly less (at least eight-fold less) for seven of the nine insect pests and apple scab, with especially dramatic reduction in incidence of the four most damaging pests: plum curculio (30-fold), codling moth (150-fold), apple maggot (150-fold) and apple scab (zero injury of orchard fruit) (Table 1). The only exceptions were tarnished plant bug (against which no protective measures were taken in the Conway orchard and injury was not significantly different from that on the unmanaged trees) and San Jose scale (whose level of injury was nil in the Conway orchard and very low on the unmanaged trees).

Discussion

Even though almost all of the elements that comprised the bottom-up, ecological approach to pest management adopted at (or shortly after) the outset remained in place across the entire two decades of Conway orchard operation reported here, there were four exceptions. First, the application of hay mulch beneath orchard trees, instituted for the second quartile (1986-90), had to be abandoned for the third and fourth quartiles (1991-00) because of buildup of damaging voles beneath the cover of mulch. Second, it was necessary to introduce use of Scare–Eye balloons during the second and for succeeding quartiles to deter wounding of fruit by birds. Third, the encouragement of growth and proliferation of all rosaceous plants in areas bordering the orchard (except for unmanaged apple, pear, hawthorn, and quince trees) had to be abandoned at the beginning of the third quartile for blackberry, whose canes supported progressive buildup of summer disease inoculum during the first two quartiles. Many large commercial orchards are equipped to remove or diminish evidence of flyspeck and sooty blotch on fruit by water-dipping and brushing fruit before sorting. Lacking such equipment, I was obliged during the second quartile to remove evidence of these diseases by wiping fruit with a damp cloth, a process that became uneconomical as yields increased with tree maturity. Hence, during the third quartile,

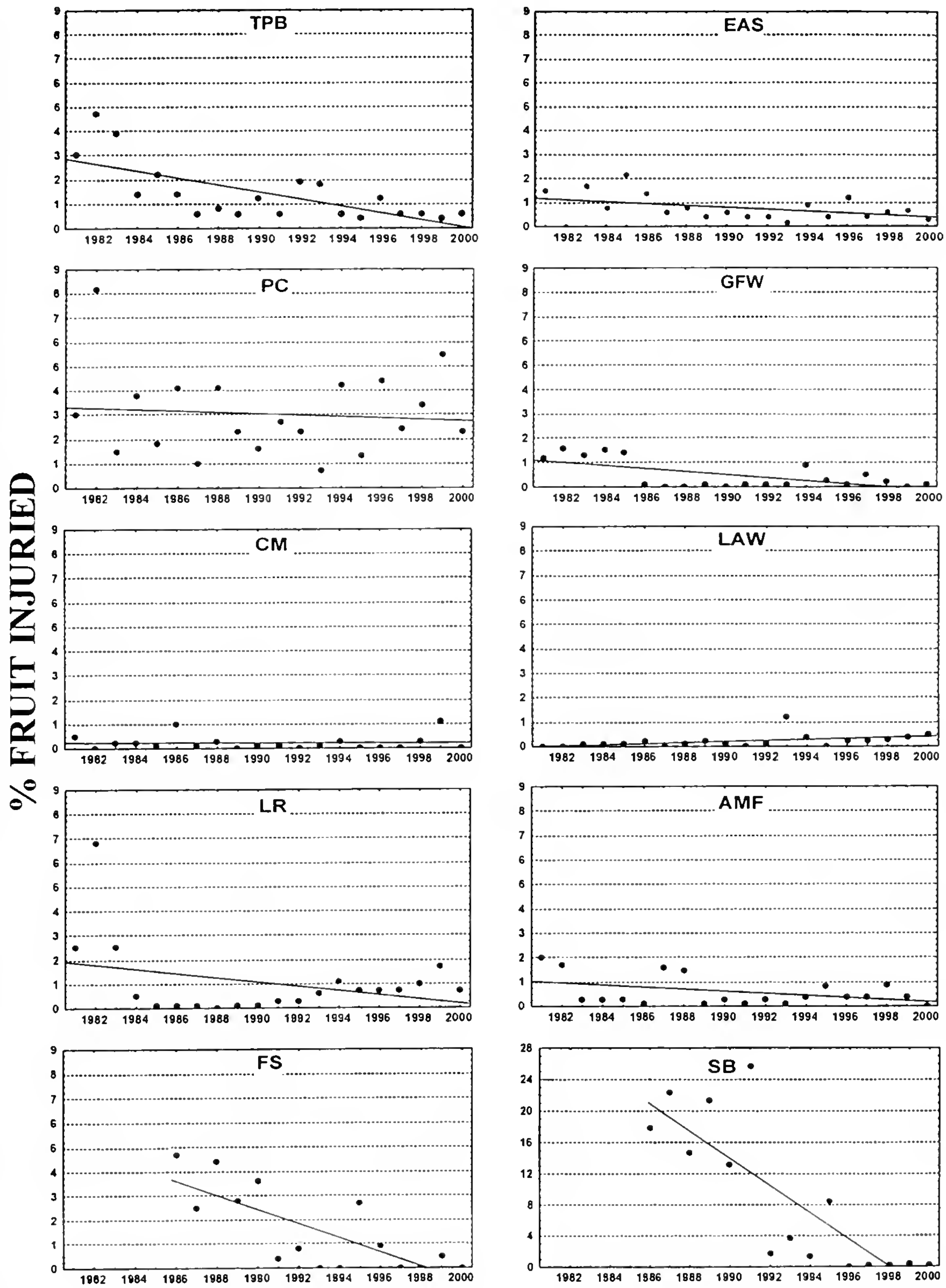

Figure 1. For each principal insect pest of fruit in the Conway orchard, the relationship between annual pest incidence and time (from 1981-2000).

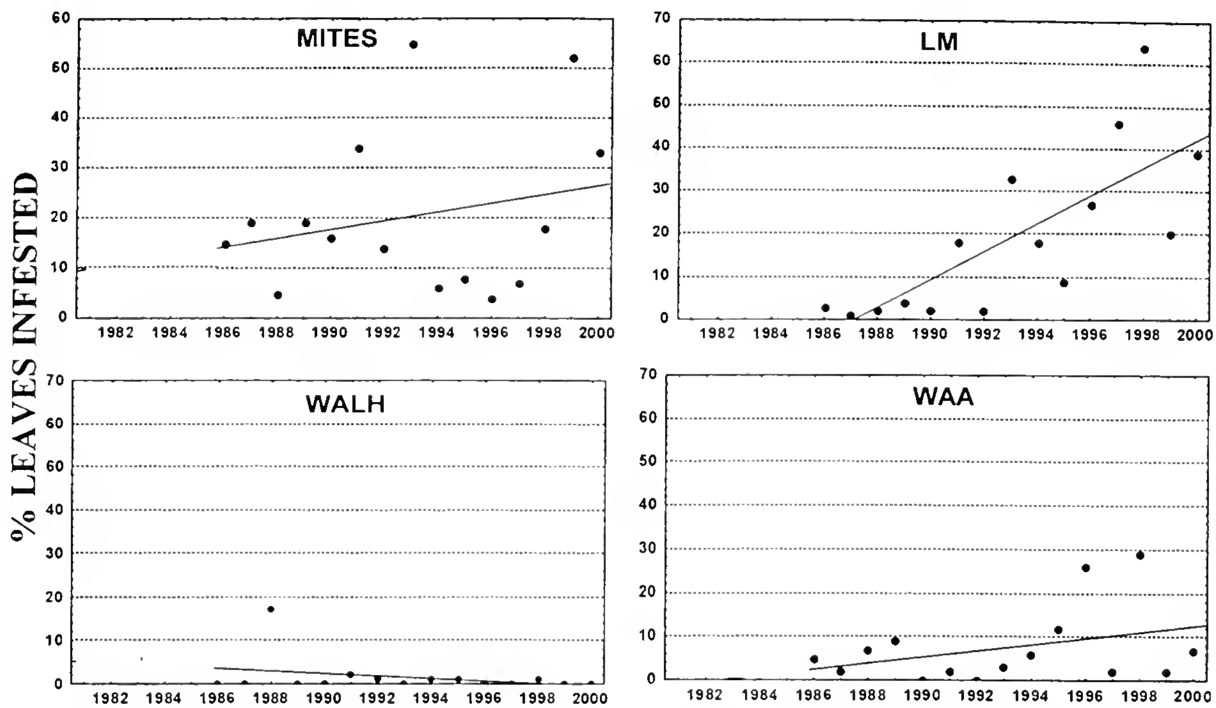

Figure 2. For each principal arthropod pest of foliage in the Conway orchard, the relationship between annual pest incidence and time (from 1986-2000).

blackberry plants (as well as grape and sumac) within 100 yards of the orchard perimeter were removed. This alone proved insufficient to reduce incidence of summer diseases to an acceptable level and was followed by application of two fungicide sprays for the fourth quartile. Finally, increasing yields associated with orchard maturity necessitated less reliance on hand removal of excess fruit as the sole approach to thinning and use, during the third and fourth quartiles, of the chemical thinner carbaryl as an amendment to phosmet in the first insecticide spray.

The only Conway orchard pest that increased significantly across the two decades of orchard operation was leafminers. The increase coincided with a shift from 100% apple blotch leafminer to 98% spotted tentiform leafminer as the dominant leafminer species in the orchard. Such a shift in leafminer composition occurred during this same time period in several large New England apple orchards, for yet uncertain reasons. The potential impact of this shift on leafminer management remains to be determined.

In another article in this issue of *Fruit Notes*, we present information on incidence across eight years (1991-1998) of codling moth, lesser appleworm and leafrollers in small blocks (about 1/2 acre) of apple trees in six large commercial orchards, wherein each block was surrounded by odor-baited spheres to control apple maggot and no insecticide was applied after mid-June. Results showed a slight but insignificant tendency toward increase of codling moth and lesser appleworm and a moderate and significant tendency toward increase of leafrollers across the eight years. The slight but insignificant trend toward increasing incidence of lesser appleworm over time in the small blocks of apple trees in commercial orchards matches a similar trend found for lesser appleworm in the Conway orchard. On the other hand, there were slight long-term trends toward decreasing numbers of codling moth and leafrollers in the Conway orchard that were inconsistent with the long-term trends toward increasing numbers of these pests in the small blocks of apple trees in the commercial orchards. Reasons for this inconsistency are unknown but could involve natural ecological processes having a greater influence

Table 1. Percent harvested fruit injured by pests in the Conway orchard and on unmanaged apple trees 200-250 yards from the Conway orchard. Data represent mean values of annual samples taken from 1981-2000[z].

	Injured fruit (%)	
Pest	Conway orchard	Unmanaged apple trees
Tarnished plant bug	1.5	2.1
European apple sawfly	0.8	7.4*
Plum curculio	3.0	94.6*
Green fruitworm	0.5	7.1*
Codling moth	0.3	45.7*
Lesser appleworm	0.2	1.7*
Leafrollers	0.6	5.7*
Apple maggot	0.6	90.8*
San Jose scale	0.0	0.5
Apple scab	0.0	40.4*

[z] Values followed by an asterisk indicate a significant difference from the corresponding value for the Conway orchard at odds of 19:1.

in the Conway orchard.

Comparison of the average level of clean (pest-free) fruit produced in the Conway orchard during 1997-2000 with that in eight large Massachusetts commercial apple orchards that practiced basic IPM and were sampled during 1997-2000 showed values of 92.8 and 92.6% clean fruit, respectively. These high levels of pest-free fruit stand in stark contrast to 0% clean fruit on Conway unmanaged trees during this same period. They were achieved with annual application of one pre-bloom horticultural oil spray, two insecticide sprays and two fungicide sprays in the Conway orchard compared with an annual average of two pre-bloom horticultural oil sprays, one acaricide spray, seven sprays containing insecticide and nine sprays containing fungicide in the large commercial orchards. Thus, the Conway orchard received pesticide sprays only about one-fourth as often as did large Massachusetts commercial apple orchards operated according to first-level IPM guidelines.

An analysis of input of purchased materials and labor for operation of the Conway orchard from 1985-89 compared with that for typical large commercial orchards of a neighboring region (eastern New York) during a similar time period revealed substantially lower input of materials and higher input of labor for operation of the Conway orchard. A similar relationship characterized operation of the Conway orchard relative to large Massachusetts commercial orchards from 1991-00. One advance that would reduce considerably the cost of labor for the Conway orchard would be substitution of reusable pesticide treated wooden spheres for sticky spheres in controlling apple maggot flies. Refined versions of the former are nearly ready for commercial use, as reported in the 2000 issue of *Fruit Notes*.

Ideally, a bottom-up ecologically based approach to management of apple orchard pests would involve no use whatsoever of any pesticide that might harm beneficial relationships among organisms inhabiting the orchard and its environs. Such may be the case (or nearly so) in apple orchards designed and maintained using practices of organic agriculture. Until very recently, it was impractical to implement sustainable commercial apple production in northeastern North America owing largely to inability to suppress plum curculio to a commercially acceptable level without use of a synthetic pesticide (such as phosmet). The recent labeling (in 1999) of kaolin clay as an organically approved material for control of plum curculio and other apple insect pests in the United States now opens the way to a potentially less disruptive ecologically-rooted bottom-up approach to growing apples than the form used here. Because kaolin clay costs about three times more per application than phosmet and requires at least four rather than two applications to achieve plum curculio control, it

remains to be seen whether the considerably greater monetary outlay associated with substituting kaolin clay for phosmet can be sustained economically. Further, kaolin clay may not be as friendly to survival of natural enemies of orchard pests as believed initially.

Conclusion

The findings of this long-term assessment of the effectiveness of a bottom-up, ecologically-based approach to apple pest management, as practiced in a small commercial apple orchard in Conway, demonstrate clearly that such a minimum-intervention approach can be conducive to sustained production of high quality apples even under high pest pressure common to orchards of Massachusetts and other New England states. Indeed, when pest incidence during the most recent four years of Conway orchard operation (1997-2000) was compared with that in large commercial orchards in Massachusetts during this same period, the amount of pest injury to fruit at harvest was essentially identical (7%) even though the Conway orchard received about 75% less insecticide and fungicide.

The question arises as to whether the bottom-up, ecological-based approach to pest management used for the past two decades in the small Conway orchard can be adopted for use when planting and maintaining larger commercial orchards. Conceivably yes. But a principal constraint lies in selling fruit of scab-resistant cultivars whose names have little or no recognition in the global marketplace. Of necessity, such apples would need to be niche-marketed in pick-your-own, roadside stand, and other similar direct-market outlets. It is among those growers whose local clientele (however limited) may have a long-term interest in purchasing apples grown under a bottom-up, ecological-based pest management approach that such an approach will have the greatest appeal.

Acknowledgements

Thanks are extended to Jennifer Mason, Arthur Tuttle, and Starker Wright for collecting the pest incidence data for large commercial orchards, to Juan Rull and Jaime Pinero for aid in data analysis for the Conway orchard, and to Wes Autio, Mark Brown, Bill Coli, and Dan Cooley for very helpful suggestions on an earlier version of the manuscript.

Do Lepidopteran Pests of Apples in Commercial Orchards of Massachusetts Increase Under Multi-year Absence of Summer Insecticide Sprays?

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Among insects that attack apples in New England, pests such as tarnished plant bug, European apple sawfly, plum curculio, and apple maggot normally are the ones against which most insecticide sprays are directed. Fortunately, we do not often experience damaging populations of lepidopteran pests such as codling moth, lesser appleworm, or leafrollers in our commercial orchards. Such lepidopteran pests are, however, an annual threat to apple quality in commercial orchards in other regions of North America.

There are two principal reasons why we usually see rather little evidence of these kinds of lepidopterans in most New England orchards. First, organophosphate insecticide sprays directed against plum curculio and apple maggot also act to control these lepidopterans. This would not be the case if the lepidopterans were resistant to organophosphates, but possible resistance has turned up in only a handful of New England orchards and only in the case of obliquebanded leafroller. Second, under the relatively cooler climatic conditions of New England, these lepidopterans rarely have more than two generations per year. In warmer climates, three or more generations are common (especially for codling moth). The threat to fruit quality increases as a direct function of number of generations per year.

Recently, some New England growers who market their apples directly to consumers have shown increased interest in adopting advanced-level integrated pest management (IPM) practices that involve controlling apple maggot with odor-baited red sphere traps rather than spraying apple maggot with insecticide. Without insecticide coverage of fruit beyond residual activity of the last spray against plum curculio in June, second generations of codling moth, lesser appleworm, and leafrollers could pose a threat to fruit quality in orchards practicing advanced-level IPM. The threat could become increasingly greater over successive years as populations build internally in orchards during July, August, and September in the absence of insecticide.

Here, we report results of a study of damage to apples by lepidopteran pests in blocks of apple trees in commercial orchards in Massachusetts where, for eight consecutive years, no insecticide was applied to the blocks after mid-June.

Materials & Methods

Each test block was about one-half acre in size and was accompanied by a nearby comparison (check) block that annually received two or three sprays of azinphosmethyl or phosmet during July and August to control apple maggot. All test blocks received odor-baited red spheres on perimeter apple trees to control apple maggot, but no insecticide after the last spray in mid-June against plum curculio. One test and one check block were located at corners of a larger block of apple trees in each of six commercial orchards. Blocks were comprised of McIntosh, Cortland, Empire, or Delicious apples. The study extended from 1991 to 1998.

Annually at harvest, 200 fruit were sampled per block for injury by lepidopteran pests.

Results

Results for each pest are presented in the form of regression lines (Figure 1) that depict a trend toward

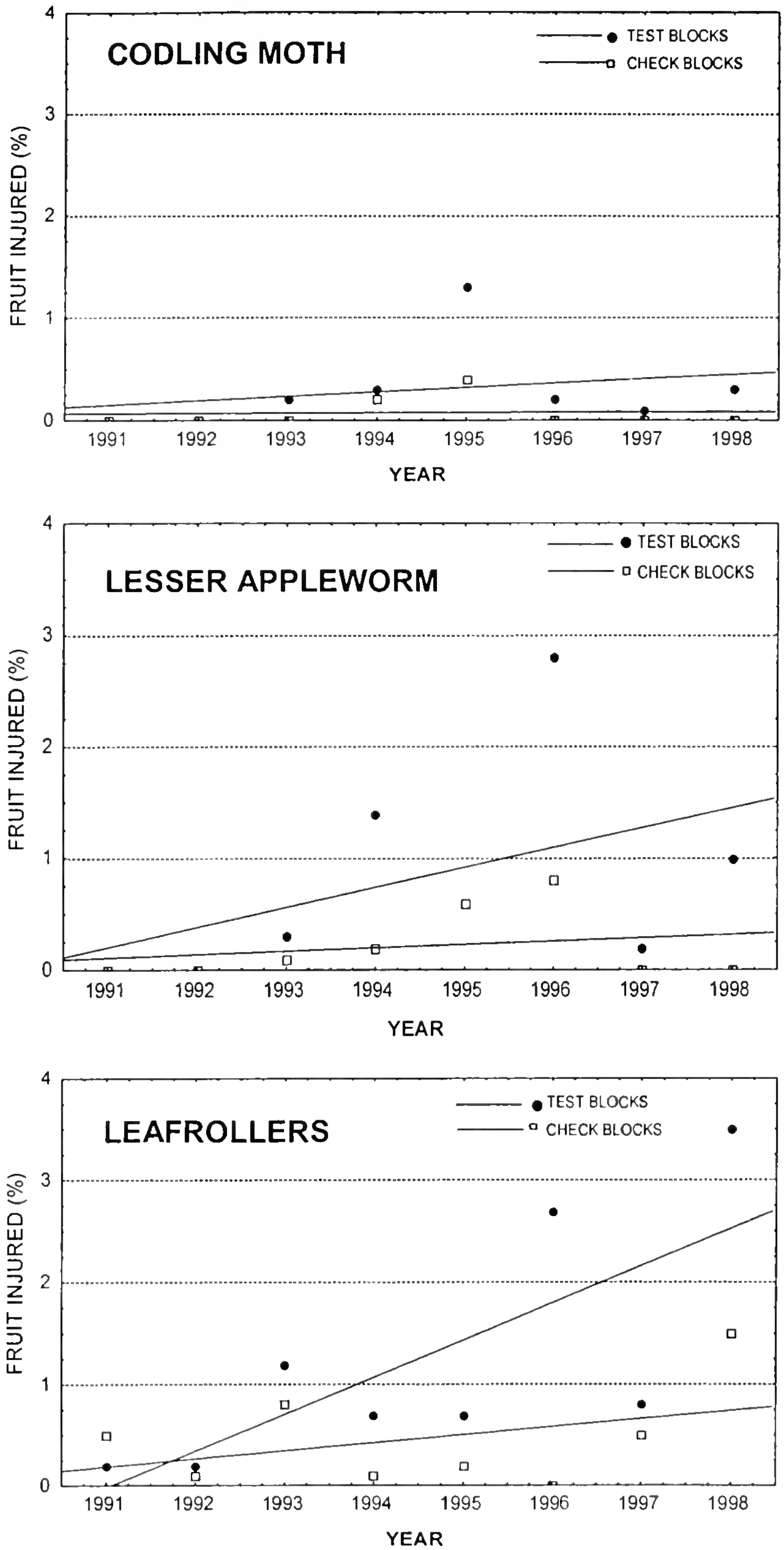

Figure 1. Regression lines showing percent fruit injured by lepidopteran pests from 1991-1998 in advanced-level IPM (test) blocks that received no summer insecticide spray and first-level IPM (check) blocks that received two or three organophosphate insecticide sprays during July and August.

an increase, a decrease, or no change in pest incidence across the 8 years of study.

For codling moth, injury across the 8 years averaged 0.3% in test blocks vs. 0.1% in check blocks (not a significant difference). The slope of the regression line indicated a slight, nonsignificant tendency toward an increase in injury by codling moth in test blocks across years, but no such tendency in check blocks.

For lesser appleworm, injury across the 8 years averaged 1.4% in test blocks vs. 0.2% in check blocks (not a significant difference). As with codling moth, the slope of the regression line indicated a slight, nonsignificant tendency toward an increase in injury by lesser appleworm in test blocks across years but no such tendency in check blocks.

For leafrollers (combined obliquebanded and redbanded), injury across the 8 years averaged 1.3% in test blocks vs. 0.5% in check blocks (not a significant difference). The slope of the regression line indicated a moderate and significant tendency toward an increase in injury by leafrollers in test blocks across years compared with only a very slight, nonsignificant tendency toward an increase in injury in check blocks across years.

Conclusion

Findings showed no increase or only a very slight increase in injury of lepidopteran pests to apples across years in check blocks to which two or three insecticide sprays were applied in July and August. In test blocks that received traps to control apple maggot but no insecticide after mid-June, injury to fruit by codling moth and lesser appleworm tended to increase slightly but nonsignificantly across years compared with a more substantial and significant tendency toward increased injury by leafrollers across years.

These findings demonstrate the value of long-term studies and suggest that among lepidopteran pests of apples in Massachusetts, leafrollers are the most likely, over several successive years, to cause increasing damage to fruit in the absence of insecticide sprays after mid-June. Fortunately, new materials such as spinosad and tefubenozide are comparatively safe insecticides that can effectively control leafrollers while inflicting relatively little harm on beneficials. Apple growers who practice advanced-level IPM should pay close attention to possible buildup of leafrollers in the absence of summer organophosphate insecticide sprays and control leafrollers with alternative measures.

Acknowledgements

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Comparison of Avaunt versus Guthion in Every-row versus Perimeter-row Sprays Against Key Apple Insect Pests: 2001 Results

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Organophosphate insecticides such as azinphosmethyl and phosmet have been the mainstay of grower control of plum curculios (PCs) and apple maggot flies (AMF) for more than three decades. Recent decisions by the EPA restrict use of these and other organophosphates on apple trees in ways that may cause growers to seek alternative approaches to controlling these key apple pests.

One possible alternative is substitution of one or more newly-labeled compounds for organophosphates. Another complementary approach is to reduce higher costs associated with adoption of newly labeled compounds by directing spray application only onto perimeter rows of apple trees, leaving the bulk of interior trees unsprayed. Previous research conducted by ourselves and others using azinphosmethyl applied only to perimeter rows of apple trees showed much promise for effective season-long control of PC and AMF. But this approach has not yet been evaluated using any of the newly-labeled compounds for control of PC, AMF and other important insect pests of apple. The rationale underlying such an approach centers upon two facts. First, nearly all PCs and AMF that invade orchards originate from host trees and overwintering sites outside of orchards. Second, immigrant PC and AMF focus their attack first on perimeter rows of apple trees before invading interior rows.

In 2001, we initiated a four-year study aimed, during the first two years, at comparing effects of indoxacarb (Avaunt) versus azinphosmethyl (Guthion) when applied to all rows versus only perimeter rows of apple trees for control of PC, AMF, and other apple insect pests.

Materials & Methods

In April of 2001, four plots were established in each of six commercial apple orchards in Massachusetts (24 plots in all). Rootstocks and cultivars varied among orchards, but all trees in a given orchard were on the same rootstock (either M.7, M.26, or M.9) and of the same cultivar (either McIntosh, Empire, Cortland, Gala, or Delicious). Each plot was about 40 x 40 yards in size and consisted of seven rows of apple trees. The perimeter row bordered woods, hedgerow, or open field and was subjected to pressure from immigrating PCs and AMF.

Growers themselves sprayed all rows of all plots with azinphosmethyl or phosmet through petal fall. Thereafter, all sprays were applied by a hired experienced applicator using our newly purchased tractor-mounted mist blower (which was not yet available at the time of petal fall). Plots in each orchard received four sprays after the petal-fall spray: 10 days and again in 20 days after petal fall against PC, and on July 18 or 19 and again on August 8 or 9 against AMF. Spray was delivered at the equivalent of 150 gallons of water per acre. Guthion (50 wp) was applied at the rate of 10 ounces of formulated material per 100 gallons against PC and 8 ounces of formulated material per 100 gallons against AMF. Avaunt (30% WG) was applied at the rate of 2 ounces of formulated material per 100 gallons against both PC and AMF.

After the petal-fall spray, plots designated as "all-row" plots received insecticide applied to both sides of trees on all seven rows, whereas plots designated as "perimeter-row" plots received insecticide sprays

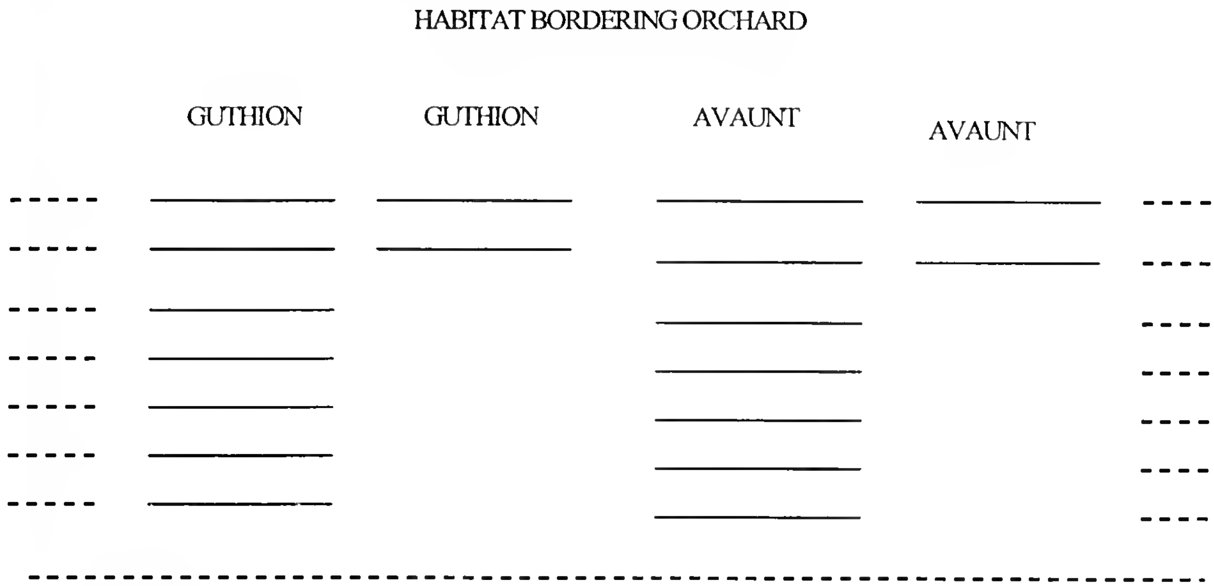

FIGURE 1. Schematic illustration of pattern of spray application in four experimental plots of a commercial orchard. Plot treatments were randomized in location within each orchard block. ___ = trees sprayed by hired applicator. _ _ _ _ = trees sprayed by grower.

Table 1. Effectiveness of Guthion versus Avaunt against pest insects when applied to all rows versus the two perimeter rows of seven-row plots in six commercial apple orchards in Massachusetts in 2001. Values represent data averaged across all samples taken in rows 1, 3, 5 and 7 of plots.

	Incidence of pest			
	Guthion		Avaunt	
Pest	All rows sprayed	Perimeter rows sprayed	All rows sprayed	Perimeter rows sprayed
Plum curculio (% trees with fruit injury)*	4.17	4.83	4.83	5.67
Apple maggot (no. captured per sphere)*	5.50	3.50	4.00	4.40
Apple maggot (% fruit with injury)*	0.23	0.27	0.16	0.35
Summer leafrollers (% fruit with injury)*	1.15	1.35	1.00	1.52
Internal Lepidoptera (% fruit with injury)*	0.00	0.00	0.00	0.00
Potato leafhopper (% terminals with injury)**	16.70	43.30	18.70	39.30

* No statistically significant differences among treatments at odds of 19 to 1.

** Statistically fewer terminals injured in each all-row than in each perimeter-row spray treatment at odds at 19 to 1.

applied to both sides of trees of the perimeter (= first) and second row but no insecticide applied to trees of the third through seventh rows (Figure 1). After the petal-fall spray, growers themselves applied azinphosmethyl or phosmet to trees in the eighth and succeeding interior rows and to orchard trees bordering plots on either side.

Weekly from petal fall until harvest in September, 100 fruit in each of rows 1, 3, 5, and 7 of each plot were sampled for injury by PC and AMF. In addition, two unbaited sticky red sphere traps were hung toward the center of each row of each plot to monitor AMF. Finally, at harvest, 100 fruit in each of rows 1, 3, 5, and 7 of each plot were sampled for injury by a variety of lepidopteran pests. At the same time, 25 foliar terminals in row five of each plot were sampled for evidence of injury by potato leafhopper.

Results

Incidence of each pest type, as averaged across all samples of fruit, foliage or traps in rows 1, 3, 5 and 7 of each plot, is given in Table 1. Results show no significant differences among any of the four treatments (all-row versus perimeter-row sprays of Guthion versus Avaunt) in incidence of fruit injury by PC, trap captures of AMF, fruit injury by AMF, or fruit injury by summer leafrollers (LR). No injury by internal lepidopterans was found. However, in interiors of plots where only the two perimeter rows were sprayed with Guthion or Avaunt, incidence of foliar terminal injury by potato leafhopper was significantly greater than in plots where all rows were sprayed with Guthion or Avaunt.

Although differences among treatments were nonsignificant, there was a trend for plot-wide incidence of injury by combined PC, AMF, and summer LR to be less in plots that received all-row sprays than in plots that received perimeter-row sprays: an average of 14% less for Guthion and 21% less for Avaunt (Table 1). When injury by these three pests was summed across all-row and perimeter-row sprayed plots, average plot-wide incidence was 12% less in plots treated with Guthion than in plots treated with Avaunt.

Data on incidence of injury by PC, AMF, and summer LR according to row are given in Figures 2-4. Results for AMF and summer LR suggest that sprays

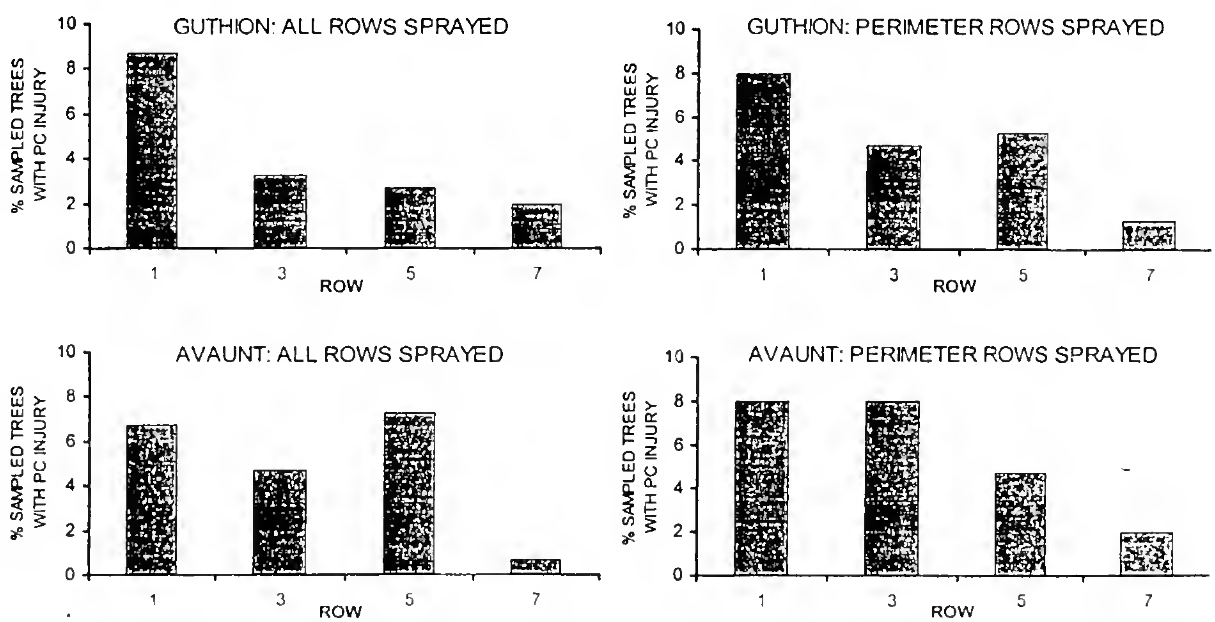

Figure 2. Incidence of plum curculio injury to fruit on trees in rows 1, 3, 5 and 7 of plots receiving either Guthion or Avaunt applied to all rows or only to the first two perimeter rows of apple trees in six commercial orchards in MA in 2001.

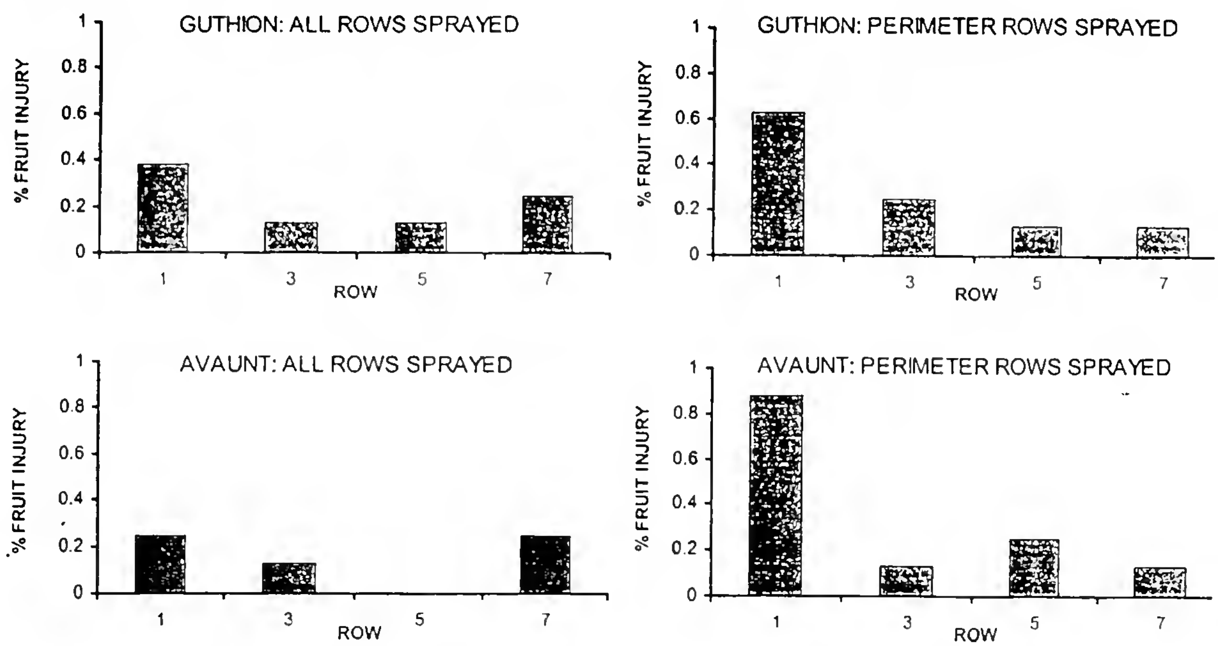

Figure 3. Incidence of apple maggot injury to fruit on trees in rows 1, 3, 5 and 7 of plots receiving either Guthion or Avaunt applied to all rows or only to the first two perimeter rows of apple trees in six commercial orchards in MA in 2001.

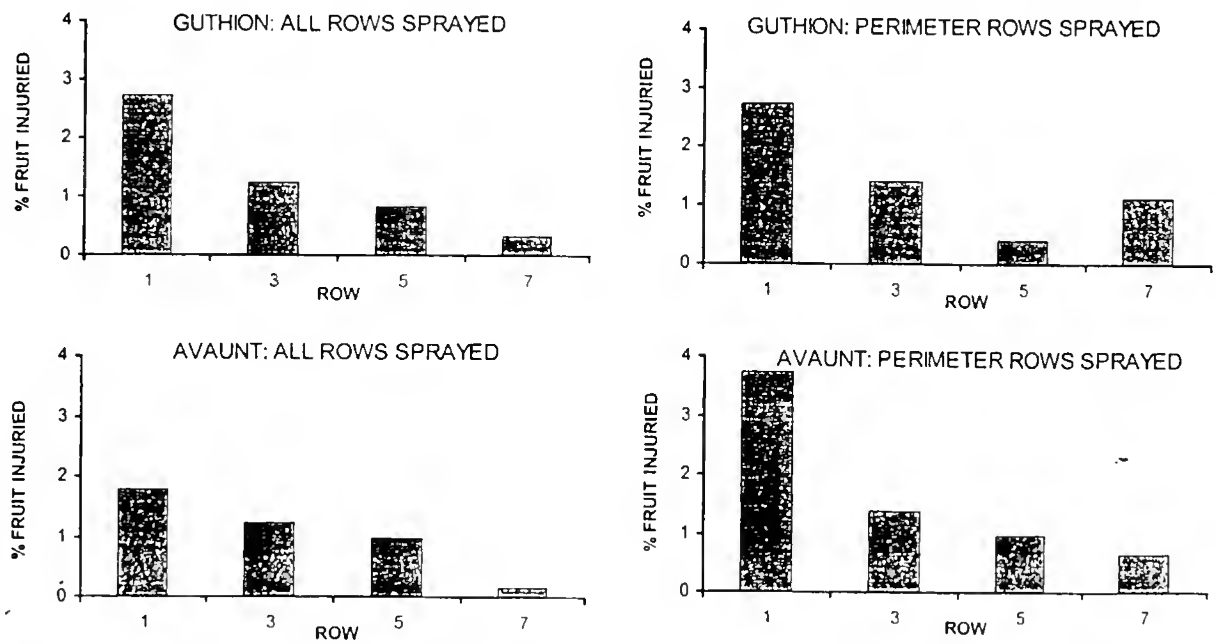

Figure 4. Incidence of summer leafroller injury to fruit on trees in rows 1, 3, 5 and 7 of plots receiving either Guthion or Avaunt applied to all rows or only to the first two perimeter rows of apple trees in six commercial orchards in MA in 2001.

of Avaunt applied only to perimeter rows were about as effective as sprays of Guthion applied only to perimeter rows and about as effective as sprays of either Guthion or Avaunt applied to all rows in preventing injury to fruit on unsprayed rows 3, 5, and 7. Results for PC suggest that sprays of Guthion applied to all rows were slightly more effective than sprays of the other three treatments in preventing injury to fruit on rows 3, 5, and 7, but differences among treatments in such injury were not significant.

Conclusions

Results of this study suggest that under the weather and pest pressure conditions that existed in six commercial orchards in Massachusetts in 2001, sprays of Avaunt (at standard recommended rate) were nearly as effective as sprays of Guthion in controlling PC, AMF, and summer LR. Moreover, sprays of either of these insecticides applied only to the first and second perimeter rows of plots were about as effective in preventing injury by AMF and summer LR in unsprayed interior rows of plots as were sprays of these insecticides applied to all seven rows of plots. Perimeter-row sprays were slightly less effective in preventing penetration and injury by PC and were ineffective in prevention penetration and damage by potato leafhoppers on unsprayed interior rows of trees.

Recent studies in other states suggest that Avaunt is just as effective as Guthion against PC but performs inconsistently against AMF. Hence, for 2002, we plan to repeat this study in the same six orchards to acquire a second year of data on the performance of Avaunt under Massachusetts conditions.

Acknowledgements

We thank Andrew Hamilton for applying all post-petal-fall sprays and the six cooperating growers: Jerry Bierne, Dave Bishop, Aaron Clark, Don Green, Tony Lincoln, and Bob Tuttle. Thanks also to DuPont Corporation for providing the Avaunt, and to Jaime Pinero and Sara Dynok for preparing the figures. This study was supported by a grant from the USDA CSREES Crops at Risk Program. orchards in MA in 2001.

* * * * *

Cultivar Preferences Affect Apple Maggot Fly Distribution in Orchards

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It has been known for decades that some apple cultivars are more susceptible to apple maggot fly (AMF) damage than others. Whether this is because trees of preferred cultivars attract more AMF than others and/or because the fruit they bear is more acceptable for oviposition than the fruit of less-preferred cultivars is not very clear. In general, it is thought that because fruit of early and mid-ripening cultivars reach a higher sugar content and soften earlier in the season, they are preferred by AMF over late-ripening cultivars (Dean and Chapman, 1973). Determining AMF cultivar preference is important because fly activity in apple orchards could concentrate in areas where preferred cultivars are found, which in turn could affect control measures using traps.

Here, we report results of a four-year experiment comparing AMF accumulation on unbaited traps among 13 apple cultivars grown in Massachusetts. Our objective was to generate cultivar preference information that would allow us to design optimal trap deployment strategies for AMF behavioral control using odor-baited traps.

Materials & Methods

We compared AMF preferences among apple cultivars grouped into three phenological categories: early, mid, and late ripening. Within each category, we selected three to six cultivars represented in New England apple orchards. Cultivar comparisons were made over a 4-year period (1997-2000) in six commercial orchards having different cultivar arrangements managed under first-level IPM practices (2-3 summer insecticide sprays against AMF).

Early-ripening cultivars included Akane, Jersey Mac, Paula Red, Red Astrachan, Tidemann Red, and Vista Bella. Mid-ripening cultivars included Cortland, Gala, and McIntosh. Late-ripening cultivars included Braeburn, Fuji, Golden Delicious, and Delicious.

Eight medium to large-size trees of each cultivar were selected in each orchard. Each tree received an unbaited red sphere coated with Tangletrap to capture alighting AMF. Spheres were placed on trees in early July and remained on trees until harvest of late cultivars in early October. Traps were inspected once per week, when captured AMF were counted and removed. Each cultivar was ranked in terms of preference by assigning a relative rank from 1 to 13, with 1 being the highest rank and 13 the lowest. The cultivar whose traps accumulated the most AMF received the highest rank.

Results

Because cultivar preferences varied along the growing season, we broke capture data into three distinct seasonal periods: early season (early July to early August), mid season (early August to early September), and late season (early September to early October). Average preference ranks among cultivars over the 4-year period reveal that during early season, two early-ripening cultivars ranked highest in terms of AMF preference: Red Astrachan and Tidemann Red (Table 1). These ranked numerically higher than Jersey Mac, Gala, Delicious, Fuji, Vista Bella, and Akane, with all other cultivars having statistically lower ranks. During mid season, Tidemann Red retained its high rank. Red Astrachan and Vista Bella, which had lost firmness and had begun dropping heavily from trees, experienced a dramatic drop in preference. Conversely, Jersey Mac and Akane, both early-ripening cultivars that ripen later than Red Astrachan, gained in average rank. Fuji gained substantially in rank while Gala retained a relatively high rank. During late season, Gala and Fuji were the most preferred cultivars. All late-ripening cultivars gained in rank. By contrast, all early-ripening cultivars (except Red Astrachan) dropped in rank. Paula Red, Jersey Mac, and Vista Bella ranked significantly lower than Gala, Fuji, and

Table 1. Average preference rank among apple cultivars according to seasonal period of captures of apple maggot flies on unbaited red sphere traps placed in trees of each cultivar.*

Early		Mid		Late	
Red Astrachan	1.0 a	Fugi	2.6 a	Gala	1.9 a
Tidemann Red	1.5 a	Tidemann Red	2.7 ab	Fuji	3.0 ab
Jersey Mac	4.1 ab	Akane	3.0 ab	Golden Del.	4.0 ab
Gala	4.3 ab	Jersey Mac	3.5 ab	Red Astrachan	4.2 abc
Delicious	4.4 ab	Gala	4.3 ab	Delicious	4.8 abc
Fuji	4.4 ab	Golden Del.	5.1 ab	Braeburn	5.5 abc
Vista Bella	4.5 abc	Delicious	5.2 b	Akane	5.7 bc
Akane	5.2 abcd	Vista Bella	5.9 bc	McIntosh	5.9 bc
Golden Del.	5.6 bcd	Red Astrachan	6.0 bc	Cortland	5.9 bc
Braeburn	6.5 bcd	Paula Red	6.2 bc	Tidemann Red	6.8 c
Paula Red	6.9 cd	McIntosh	6.7 bc	Paula Red	7.1 c
McIntosh	7.0 d	Braeburn	7.5 c	Jersey Mac	7.5 c
Cortland	7.5 d	Cortland	8.0 c	Vista Bella	8.1 c

* Values within a column followed by the same letter are not significantly different at odds of 19:1.

Golden Delicious. The early ripening cultivar Paula Red and the mid-ripening cultivars McIntosh and Cortland always ranked among the bottom six cultivars in terms of preference.

Discussion

Traps on early cultivars, with the exception of Paula Red, accumulated substantial numbers of AMF during the early and/or mid period of the AMF season. Preference among early cultivars appeared to shift depending on ripening stage and the onset of fruit drop or harvest. For mid-ripening cultivars, traps on Gala accumulated relatively high numbers of AMF in most years and in most orchards early in the season, maintained their high preference rank across mid season, and reached their peak late in the season. With the exception of trees of a specific strain (Rogers Red McIntosh), and trees at one locale in one year (Cortland), traps on McIntosh and Cortland accumulated few AMF. Among late-ripening cultivars, traps on Fuji trees accumulated large numbers of flies during mid and late season. Both Delicious and Golden Delicious accumulated moderate numbers of AMF early in the season. By late season, these two late-ripening cultivars, along with Braeburn, reached a comparatively high rank.

Cultivar composition strongly influenced AMF distribution in orchards in our study. Contrary to earlier findings (Murphy et al., 1991), we found that AMF preference for some apple cultivars is not governed exclusively by the time of fruit ripening but rather by specific properties of fruit, possibly odor composition. Indeed, in some cases more than 80% of total AMF captures in a trapping period occurred on traps placed on trees of a single mid-ripening and a single late-ripening cultivar (Gala and Fuji). Moreover, AMF accumulated in considerable numbers on traps on Fuji trees in mid-season, despite the fact that those trees bore relatively unripe green fruit at that time. Findings here, in combination with findings on AMF oviposition preferences among cultivars (see following article), could have a substantial influence on success of using odor-baited traps to control AMF.

Acknowledgements

We thank Dave Cheney, Tom Clark, Dave Shearer, Joe Sincuk, Tim Smith, and Bob Tuttle for allowing us to use their orchards. We are grateful to Monica Elmore, Beata Rzasa, Jaime PiDero, Anthony Minalga, Alejandro Garza, Brian Hogg, Gianumberto Accinelli, Susan Nixson, Katie Bednaz, Amanda Ross, and Steve Lavalee for excellent technical assistance. This work was supported by USDA National Research Initiative Competitive Grant 95-COOP-1-0482, and a USDA Northeast Regional Competitive IPM grant.

References

Dean, R.W. and P.J. Chapman. 1973. Bionomics of the apple maggot in eastern New York. Search 3: 1-58.

Murphy, B.C., L.T. Wilson and R.V. Dowell. 1991. Quantifying apple maggot preference for apples to optimize distribution of traps among trees. Environmental Entomology 20: 981-987.

* * * * *

Apple Maggot Fly Ovipositional Preferences for Fruit of Different Apple Cultivars

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In the preceding article, we reported on apple maggot fly (AMF) preferences among 13 different cultivars of apple. Preference for different cultivars was established by determining which cultivars accumulated the most AMF on traps placed on trees of different cultivars in six commercial orchards over four years.

Because cultivar susceptibility is the result of both the degree to which AMF are attracted to apple trees of different cultivars and their propensity to lay eggs in the fruit they find on trees of those cultivars, we decided to evaluate AMF ovipositional preferences for fruit of 12 of the 13 cultivars of apples that were evaluated in our previously reported field experiment.

Combined results of both studies were employed to establish overall ranking of cultivar susceptibility to AMF.

Materials & Methods

AMF ovipositional preferences among five early-ripening cultivars (Akane, Jersey Mac, Paula Red, Tidemann Red, and Vista Bella), three mid-ripening cultivars (Cortland, Gala, and McIntosh), and four late-ripening cultivars (Braeburn, Fuji, Golden Delicious, and Delicious) were examined. Apples were picked from trees in six commercial orchards on a weekly basis during the growing season (early July to early October) over a 4-year period.

A single apple of each of 12 cultivars was then washed to remove pesticide residue and placed in a 30x30x30 cm Plexiglas cage along with 5-10 mature AMF females. Apples were left in cages for a period of 24-48 hours, after which they were examined for oviposition stings under a microscope. Sugar content of apples was determined with a hand refractometer, and pulp firmness was measured with a penetrometer.

To determine AMF ovipositional preferences, each cultivar was assigned a rank from 1 to 12, with 1 being the highest rank and 12 the lowest. The cultivar having the largest proportion of apples accepted for oviposition in a given seasonal period in a given year received the highest rank. We then averaged cultivar ranks across years and compared cultivar acceptance using appropriate statistical methods.

Results

Average ovipositional preference ranks of cultivars at different seasonal periods are shown in Table 1. During early season, the earliest ripening cultivars (Tidemann Red and Vista Bella) ranked significantly higher than some mid-ripening (Gala) and all late-ripening cultivars. During mid-season, early-ripening cultivars that maintained a high flesh firmness (Akane, Tidemann Red, and Jersey Mac) and two mid-ripening cultivars (Gala and McIntosh) received significantly higher ranks than late-ripening cultivars of Delicious, Fuji, and Golden Delicious and an early ripening cultivar that had become too soft (Vista Bella). During late season, all three mid-ripening cultivars were preferred over all four late-ripening cultivars, despite the fact that some of the late-ripening cultivars had acquired a high sugar content and moderate pulp firmness.

Discussion

During early season, AMF preferred to oviposit in sweeter and softer fruit of early cultivars such as Tidemann Red and Vista Bella than in fruit of other cultivars. During mid season, AMF continued to prefer to oviposit in fruit of early cultivars that had not become too soft. Early cultivars ripening slightly later (Jersey

Table 1. Average ovipositional preference rank among apple cultivars according to seasonal period.*

Early		Mid		Late	
Tidemann Red	1.2 a	Akane	1.5 a	McIntosh	1.5
Vista Bella	3.2 ab	Tidemann Red	2.2 ab	Gala	2.0
Jersey Mac	3.5 abc	Jersey Mac	2.8 ab	Cortland	2.5
Cortland	4.1 bcd	McIntosh	2.9 ab	Paula Red	4.0
McIntosh	4.9 bcd	Gala	3.0 ab	Braeburn	4.0
Paula Red	5.0 bcd	Braeburn	4.5 bc	Fuji	5.0
Gala	5.4 cde	Paula Red	5.8 cd	Tidemann Red	6.0
Akane	5.9 def	Cortland	6.1 cd	Red Delicious	6.0
Fuji	7.5 efg	Delicious	7.4 de	Golden Delicious	7.5
Braeburn	8.2 efg	Fuji	7.6 de		
Delicious	8.3 fg	Vista Bella	9.0 e		
Golden Del.	8.5 g	Golden Del.	9.5 e		

* Values within a column followed by the same letter are not significantly different at odds of 19:1. Certain circumstances disqualified results of late-season tests for statistical analysis.

Mac and Akane), along with mid-ripening cultivars (McIntosh, Gala, and Cortland to a lesser degree) and a late ripening cultivar (Braeburn) became acceptable for oviposition during mid season. During late season, all three mid-ripening cultivars (McIntosh, Gala, and Cortland) were the most acceptable for oviposition. Acceptance of late-ripening cultivars was moderately high in 1999, but remained low in 2000 despite the fact that apples of those cultivars had become sweet.

Interestingly, AMF cultivar preferences in terms of accumulation on traps in our field study and ovipositional acceptance here were not always in accord. Some cultivars were both highly attractive (or highly arrestive) as well as highly acceptable for oviposition (Akane, Gala, Jersey Mac, and Tidemann Red) and therefore should be considered as highly susceptible to AMF damage. Other cultivars accumulated large or substantial numbers of AMF but bore fruit comparatively unacceptable to ovipositioning females (Fuji, Golden Delicious, and Delicious), or failed to accumulate large numbers of AMF despite the fact that they bore highly or substantially acceptable fruit (McIntosh, Cortland, and Braeburn). Such cultivars can be considered as being moderately susceptible to AMF damage. Finally, cultivars that were both comparatively unattractive and comparatively unacceptable should be considered as tolerant or of low susceptibility to AMF (e.g., Paula Red).

Conclusions

Combined findings of an earlier study on the influence of tree size and planting density on AMF (Fall 1999 issue of *Fruit Notes)*, the preceding study on cultivar susceptibility to accumulation of AMF, and this study on cultivar susceptibility to AMF oviposition suggest that orchard architecture could have a strong impact on the success of behavioral control of AMF with traps.

For example, an ideal type of orchard architecture to achieve maximum AMF control using odor-baited spheres placed on perimeter-row apple trees (to intercept immigrating AMF) might be as follows: plant trees on dwarfing rootstock (M.9 or M.26) and arrange cultivars in such a way that late-ripening cultivars such

as Fuji, Golden Delicious, or Delicious comprise the perimeter rows that face woods or hedgerows, which are more likely to be colonized by immigrant AMF than are perimeter rows facing open field (see following article). Our previous work has shown that AMF control using perimeter-row traps is better on smaller, high-density trees than on larger, low-density trees. Results given in the preceding article and here suggest that cultivars such as Fuji (in particular) but also Golden Delicious and Delicious are highly or at least moderately attractive to (or arresting of) AMF but are relatively low in susceptibility to AMF oviposition. In concept, immigrant AMF would preferentially accumulate on these cultivars and have a high probability of being eliminated by traps before laying eggs in the comparatively non-susceptible fruit or moving toward the interior of the orchard. Conversely, an architectural arrangement that is likely to be minimally conducive to AMF control using perimeter-row traps might be one where cultivars that are both highly attractive to (or arresting of) AMF and highly susceptible to AMF oviposition (e.g., Gala, Jersey Mac, Tidemann Red) are planted on perimeter rows, especially where perimeter rows border woods or hedgerows.

Acknowledgements

We thank Dave Cheney, Tom Clark, Dave Shearer, Joe Sincuk, Tim Smith, and Bob Tuttle for allowing us to use their orchards. We are grateful to Monica Elmore, Beata Rzasa, Jaime PiDero, Anthony Minalga, Alejandro Garza, Brian Hogg, Gianumberto Accinelli, Susan Nixson, Katie Bednaz, Amanda Ross, and Steve Lavalee for excellent technical assistance. This work was supported by USDA National Research Initiative Competitive Grant 95-COOP-1-0482, and a USDA Northeast Regional Competitive IPM grant.

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Improvement of Sugar-delivery Systems for Rain-activated, Pesticide-treated Spheres

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Introduction

Through use of odor-baited sticky red spheres, effective behavioral control of apple maggot is possible and has been widely reported in *Fruit Notes*. However, the sticky material used to snare alighting apple maggot flies (AMF) is very difficult to handle and requires frequent maintenance. In order to develop trap-based AMF control that is practical for commercial adoption, we have worked for many years toward development of pesticide-treated spheres (PTS) to substitute for inefficient sticky-coated spheres. Although PTS have shown great promise in both laboratory and field trials, the major challenge we face is continuously supplying the sphere surface with enough sugar to stimulate fly feeding, thereby allowing PTS to achieve maximum toxicity to AMF with a minimal dose of insecticide. To date, we have developed two approaches to providing a consistent supply of sucrose to sphere surfaces under field conditions: a reusable wooden PTS with an external source of feeding stimulant and a disposable sugar/flour PTS whose entire body consists of sugar and starches (see *Fruit Notes*, Volume 65).

Data from field and laboratory trials in 2000 strongly suggest that wooden PTS retain toxicity to AMF for at least 12 weeks, while sugar/flour PTS may begin to lose their toxic effects after as little as six weeks of field exposure. From direct observations of fly feeding on PTS and assessments of fly behavior after exposure, it appears that, along with some sugar, some toxicant is lost from the sugar/flour PTS during rainfall. Given this, we believe that further development of re-usable wooden PTS may hold greater long-term promise for commercially viable behavioral control of AMF than do sugar/flour PTS.

Since 1997, we have worked toward development of a wooden PTS system focusing on use of a sucrose-bearing top-cap affixed to each sphere which, under rainfall, releases a small amount of sucrose onto the sphere surface. Thus, as surface sugar is dissipated under rainfall or heavy dew, it is replaced with sucrose from a source atop the PTS. In 1997 and 1998, we attempted to form these caps of nearly pure sucrose, finding quickly that the pure sugar caps were highly prone to breakdown under conditions of high humidity. In 1999, we formed and tested flat-topped, 1 ½" caps consisting of 85% sucrose bound in 15% paraffin (25 grams total mass). Although these caps worked for a short time in the field (~3 weeks), they ran out of sugar well before the close of the season.

In 2000, we again tested caps consisting of 85% sucrose bound in 15% paraffin, but modified the caps in 3 major ways: 1) we increased the diameter to 2 inches; 2) we doubled the mass to 50 grams; and 3) we formed the caps using a hydraulic press that stamped eight flutes into the top of each cap, ensuring even distribution of sucrose-bearing runoff. Upon lab testing, this style of cap was effective through five inches of accumulated rainfall (roughly equal to five weeks of field exposure). This was by far the best-performing wooden PTS to date, but we needed to address two major shortcomings: 1) further modification of caps to ensure effectiveness through at least mid-season (six to eight inches of rainfall), and 2) prevention of rodent damage to caps. From the laboratory-based studies reported here, our goal was to improve the consistency and durability of sugar release from wax/sugar caps for deployment on wooden PTS in 2001.

Materials & Methods

For each of the trials described below, we mounted experimental caps on 3.3-in wooden spheres prior to

artificial rainfall exposure. Sucrose bound in each cap was stained with a water-soluble, food-grade dye to permit visual observation of the movement and relative concentration of sucrose dissolved in runoff water. In addition, spheres were painted gloss white to allow maximum visual interpretation of sucrose coverage and distribution. All runoff water from each sphere was collected and tested for sucrose content using a Brix scale assessed with an Atago hand refractometer (0-32%, +/-0.1%).

In our first experiment, we varied the concentration of paraffin in each cap to assess the impact of paraffin content on sugar output and cap durability. We formed two-inch fluted caps (50 grams each) containing 10%, 15%, 20%, or 25% paraffin, and subjected five replicates of each disc type to eight inches of artificially applied rainfall. In all trials of these caps, rain was applied at a rate of one inch per hour, and spheres received no more than one inch per day to simulate the periodic rains of summer field conditions. After each inch of rainfall, we calculated the total mass of sugar put out by each cap, the mass of sugar lost to rainfall (by collecting and analyzing runoff water from each sphere), and the amount of sugar left on the surface of each sphere. Initial data drawn from caps containing 15% and 20% paraffin were encouraging, leading us to test the acceptability of spheres to flies after two, four, six, and eight inches of rainfall. In this trial, 50 flies were exposed (individually) to each treatment. Flies were allowed to forage freely on spheres for a maximum of 600 seconds. Total residence time and time spent feeding were recorded for each fly.

In our second experiment, we varied the total mass and diameter of caps in an attempt to heighten both the concentration and duration of the sugar output of each cap. For this trial, we produced three types of caps: 1) 2-inch diameter, 50 grams, fluted; 2) 2-inch diameter, 75 grams, fluted; and 3) 2½-inch diameter, 75 grams, fluted. As in the previous experiment, we subjected five replicates of each cap type to eight inches of artificially applied rainfall in one-inch increments. After each rainfall interval, we assessed the total mass of sugar put out by each cap, the mass of sugar lost to runoff, and the amount of sugar left on the surface of each sphere. Given the limited success of either of the larger caps, we did not perform fly feeding tests on any spheres in this experiment.

In our third experiment, we attempted to enhance the performance of sugar-release caps by capitalizing on the observation that a small amount of water is absorbed by and moves through the paraffin/sucrose matrix of each cap. To enhance the availability of sucrose bound within the wax matrix, we reshaped our 2000 field-standard caps (15% paraffin, 2-inch diameter, 50 grams) such that eight shallow reservoirs were pressed into the top of each cap. As an alternative to fluted caps that channel rainfall off of wax/sugar caps, these caps were designed to retain a small amount of water (roughly five milliliters) in reservoirs atop each cap, allowing held water to percolate through the slightly porous cap body. This percolation effect has four advantages over previous cap styles: 1) the slowly developing sucrose-bearing runoff is highly concentrated to consistently stimulate fly feeding; 2) very little sucrose runs off onto fruit and foliage beneath traps, limiting fungal growth; 3) the entire mass of sucrose in each cap is eventually used, dramatically increasing the endurance of each wooden PTS; and 4) a very small amount of rainfall or dew (less than 0.1 inch) is needed to recharge the spheres with sucrose. In this experiment, we directly compared these modified caps with our 2000 field standard. As in previous trials, five spheres of each type were exposed to artificially generated rainfall in 1-inch increments. After each rainfall interval, we assessed the total mass of sugar put out by each cap, the mass of sugar lost to runoff, and the amount of sugar left on the surface of each sphere.

Our final experiment in this trial aimed at deterring rodents from feeding on field-deployed wax/sugar caps atop wooden PTS. Up to and during the 2000 field season, we tested chemical additives (cayenne pepper and bitter watermelon concentrate) for their ability to deter rodent feeding on caps. Field and laboratory data from these trials concluded that bitter watermelon extract (up to 5% concentration) had no rodent-deterrent effect, while cayenne pepper (up to 10% concentration) had only little deterrent effect. Further, the negative impact of these additives on cap structural integrity far outweighed the potential benefits of rodent deterrence. Therefore, we determined that a physical barrier must be integrated into the sphere/cap system to bar rodents from reaching and damaging the vulnerable wax/sugar caps. We constructed five types of wire guards (all formed of 1/8-inch grid hardware cloth) for wax/sugar caps atop wooden PTS: 1) bottom guard only, 2) top guard only, 3) side guard only, 4) reusable top/side guard combination, and 5) fixed top/

bottom/side guard combination. Five caps of each treatment along with five unprotected caps were placed atop spheres and offered to numerous and remarkably aggressive wild gray squirrels. Assessments of physical damage (as percentage of cap mass consumed) were made daily for two weeks after deployment.

Results

As hypothesized for our first experiment, wax/sugar discs formulated with lower rates of paraffin (10%-15%, Table 1) released a greater amount of sugar under rainfall than discs formulated with higher rates of paraffin (20%-25%). Although superior at the outset, discs formulated with the lowest rate of paraffin (10%) only released an acceptable amount of sucrose (>5.0 grams per inch of rain) through four inches of artificially applied rainfall. Conversely, caps formulated with the greatest amount of paraffin (25%) never provided an adequate release of sucrose. Caps formulated with 15% paraffin performed somewhat better, offering an acceptable release of sugar through five inches of accumulated rainfall, and caps formulated with 20% paraffin released slightly less sugar than those formulated with 15% paraffin through the first six inches of rainfall. However, sugar release from caps of 20% paraffin was by far the most consistent through simulated mid-season treatments (four to eight inches accumulated rainfall). Therefore, we elected to conduct bioassays comparing acceptability of spheres equipped with caps formulated with 15% and 20% paraffin.

In the first half of bioassays (two to four inches of rainfall), feeding response of flies placed on spheres equipped with wax/sugar caps was excellent and equal between treatments (Table 2). In fact, through four inches of rainfall, both treatments yielded mean feeding times far greater than needed to ensure adequate uptake of toxicant. Further, both treatments stimulated 86% of exposed flies to feed for more than 30 seconds, suggesting that both density and coverage of sucrose on sphere surfaces remained sufficient after four inches of rainfall. After six inches of rainfall, however, neither treatment fared well. Effectiveness of spheres fitted with 15% paraffin caps retained only one-eighth of their feeding stimulant power after six inches of rainfall, while spheres fitted with 20% paraffin caps retained only one-half. Along with reduced duration of feeding, far fewer flies were willing to feed on spheres at all, strongly indicating that after six inches of rainfall, neither treatment could be reliable as a control mechanism for AMF.

In our second experiment, we compared the sugar

Table 1. Mean release of sucrose from experimental wax/sugar caps. Data indicate mass of sucrose (grams) in runoff water after exposure to artificially generated rainfall. Sugar release greater than 5.00 grams per inch of rainfall is needed to reliably stimulate fly feeding. All tested caps were 50 grams total mass, 2-inch diameter, fluted design.

	Sphere cap formulation (% paraffin)			
Rainfall (inches)	10	15	20	25
1	6.54	4.95	3.68	2.45
2	5.00	5.97	5.02	2.27
3	6.20	5.27	4.01	2.30
4	5.46	6.17	5.77	2.04
5	4.55	5.22	4.60	2.36
6	3.18	3.76	3.57	1.42
7	2.02	2.43	3.37	1.06
8	0.91	1.70	3.05	0.61
Total (grams)	33.86	35.47	33.07	14.51
% Sugar Released	75.2	83.5	82.7	38.7

Table 2. Duration and propensity of apple maggot fly feeding on spheres equipped with wax/sugar caps after exposure to artificially generated rainfall. For each treatment, 50 flies were exposed (individually) and allowed to forage freely on spheres for a maximum of 600 seconds.

	Mean fly feeding time (sec.) Sphere cap formulation		Flies feeding >30 seconds (%) Sphere cap formulation	
Rainfall (inches)	15%	20%	15%	20%
2	366.7	439.1	84.0	88.0
4	403.3	340.7	86.0	86.0
6	54.0	163.1	24.0	52.0
8	46.1	68.4	16.0	28.0

Table 3. Comparison of release of sucrose by two styles of wax/sugar caps and comparison of retention of released sucrose on wooden spheres.

	Sugar (grams) in runoff water Sphere Cap Style		Sugar (mg/cm^2) retained on sphere Sphere Cap Style	
Rainfall (inches)	Fluted	Reservoir	Fluted	Reservoir
1	4.95	2.55	3.3	11.3
2	5.97	1.85	2.7	7.0
3	5.27	1.69	2.5	5.3
4	6.17	1.54	2.4	4.5
5	5.22	1.45	2.2	4.4
6	3.76	1.27	1.7	4.2
7	2.43	1.16	1.1	3.9
8	1.70	1.14	0.8	3.8
Total (grams)	35.47	12.65		
% Sugar Released	83.5	29.8		

release from caps of varying sizes. By increasing the cap height by 50%, our intent was to maintain steady sugar release over a longer period. Unfortunately, increasing cap height did not enhance either concentration or duration of sugar release. By increasing the cap diameter to 2 ½", we were able to substantially increase the amount of sugar put out by each cap. However, by extending the outer edge of the cap closer to the diameter of the sphere, we eliminated the potential for even coverage by sugar-bearing runoff. It was apparent under visual observation of the movement of stained sucrose that although we had drastically increased the amount of sugar put out by each cap, very little released sugar remained on the sphere surface. Therefore, we abandoned any further testing of fluted wax/sugar caps larger than 2-inch diameter.

Although the previous experiment did not yield an improvement over our 2000 field-model sugar-release caps, we found that all caps tested retained a substantial amount of sucrose within the cap bodies long after they had stopped releasing sugar to the sphere surfaces. Unfortunately, with a fluted cap style (reliant on release of sugar from the outside surfaces of the cap), the remainder of solid sucrose is too deeply embedded in the wax matrix to be readily available for dissolution in rainfall. However, by direct observation of the movement of rainfall onto and off of these caps, we determined that a small amount of water moves slowly through the wax matrix and is released to the sphere surface at the bottom of the cap. For our third experiment, we compared the rate of sugar release from fluted caps versus release from new caps partitioned at the top to allow retention of a small reservoir of water. In assessments of sucrose found in runoff, fluted caps were superior (Table 3), maintaining greater than five grams of sugar release per inch of rainfall through five accumulated inches, while reservoir-style caps never exceeded three grams of sucrose release. However, visual observations indicated that both coverage and concentration of sucrose on spheres after drying were far greater on spheres fitted with new reservoir-style caps. This observation was confirmed by subsequent measurements of residual sucrose on the sphere surface (Table 3).

In our final experiment, we assessed the effectiveness of five types of rodent guards, all formed of hardware cloth. After only a day of exposure to wild gray squirrels, any caps with any unprotected surface were severely damaged. After one week, all caps were consumed entirely, with the exception of those fitted with an embedded top/bottom/side guard combination. At the close of the two-week trial, all of these fully protected caps remained intact, although the integrity of the guard system showed signs of wear. We are confident, though, that caps constructed with a fully integrated wire guard can withstand the more lenient assaults of standard orchard-dwelling rodents.

Conclusion

Given the variables of wax type, cap formulation and size, shape, and density of cap, a vast array of sugar release systems remain to be tested for use on pesticide-treated wooden spheres. However, through trials to date, we have arrived at an improved sugar delivery system for testing under commercial orchard conditions. Although these caps are still under study, their performance has exceeded any other style tested to date, and they hold the potential to markedly enhance the effectiveness, practicality, and commercial viability of wooden PTS. We will carry forward with field trials of spheres equipped with the style of caps developed here: 2-inch diameter, 15-20% paraffin, 50 grams total mass, reservoir design, formed under 20 tons of pressure, and fitted with an integrated rodent guard.

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Commercial Orchard Evaluation of Pesticide-treated Spheres for Apple Maggot Control in 2001

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In the 2000 issue of Fruit Notes, we described results of year-2000 orchard trials of pesticide-treated spheres (PTS) for controlling apple maggot flies (AMF). These trials involved evaluation of biodegradable sugar/flour PTS as well as wooden PTS topped with a disc composed of sugar and wax. We found that neither type of PTS approached optimal efficacy. Sugar/flour PTS suffered progressive loss of toxicant under rainfall as well as progressive loss of sphere integrity due to consumption of spheres by rodents and other mammals. Wooden PTS maintained a high level of residual toxicant throughout the summer of 2000, but the top caps did not retain enough sugar to stimulate consistent feeding of AMF on the sphere surface after 4-5 inches of rainfall and, like sugar/flour spheres, were vulnerable to consumption by rodents and other mammals.

In the preceding article in this issue of Fruit Notes, we describe recent laboratory research that gave rise to an improved type of sugar/wax disc for placement atop a wooden PTS. Here, we describe commercial orchard trials conducted in 2001 comparing the effectiveness of wooden PTS topped by improved sugar/wax discs with the effectiveness of standard sugar/flour PTS and sticky-coated spheres for controlling AMF.

Materials & Methods

The improved sugar/wax discs had the following properties: a size of 2 inches diameter by 3/4 inch tall; a composition of 85% sucrose and 15% paraffin wax (50 grams total mass); a top surface into which eight shallow reservoirs were pressed to permit retention of a small amount of water that could percolate through the slightly porous body of the disc; a hardness that resulted from compression under 20 tons of hydraulic pressure; and an embedded wire guard surrounding the disc to protect it from consumption by rodents. Red vegetable dye was mixed with the sucrose to color each disc red. The dye was absorbed by the sugar. As the amount of sugar diminished under rainfall or dew, so also did the color of the disc change from red to pink and eventually white. This allowed visual assessment of the relative amount of sugar remaining in the disc. A disc was positioned atop each 3.25-inch wooden PTS by unscrewing the metal shaft holding the sphere, pushing the shaft through the small hole at the center of the disc and then reattaching the shaft to the sphere. The sphere received a coat of black latex paint containing 4% (a. i.) imidacloprid (Provado). Water containing 20% sucrose was sprayed on each wooden PTS just before deployment.

Sugar/flour spheres likewise were 3.25 inches diameter, coated with black latex paint containing 4% (a. i.) imidacloprid (Provado) and were purchased from FruitSphere Inc. (Peoria, Illinois). Except for substitution of black for red latex paint and an increase in amount of imidacloprid from 2 to 4% a. i., sugar/flour spheres were the same as those we evaluated in orchard trials in 2000.

Sticky spheres were 3.25 inches in diameter, red in color, and coated with Tangletrap to capture alighting AMF.

Spheres were evaluated in six commercial orchards in MA, each of which contained four small plots of apple trees (~ 49 trees per plot). Three of the plots received no insecticide after mid-June and were surrounded by either wooden PTS, sugar/flour PTS, or sticky spheres placed about 5 yards apart on perimeter trees during the first week of July. Each sphere was baited with a vial of butyl hexanoate. The

fourth plot received two or three sprays of phosmet to control AMF. Discs atop wooden spheres and all sugar/flour spheres were replaced at mid-season (after 6 weeks of field exposure) with fresh versions of each. Treatment effectiveness was judged by comparing numbers of feral AMF captured on interior unbaited monitoring traps (four traps on central trees of each plot) and percent injury to fruit in samples taken every other week from July to September.

In addition to measurements of whole-plot treatment effectiveness, we assessed the structural durability of each PTS bi-weekly from July to September. For these assessments, we recorded the percentage of spheres impacted by feeding of rodents or other mammals on discs atop wooden spheres or on the body of sugar/flour spheres. For each of four sample sites, we also recorded the amount of rainfall accumulated during each bi-weekly period as a factor potentially leading to premature breakdown of sphere effectiveness (through wash-off of sugar and/or toxicant).

At the mid-point (6 weeks of sphere exposure) and end (12 weeks of sphere exposure) of our trial, we retrieved two randomly-chosen but intact PTS of each type from each orchard and returned them to the laboratory for testing. We directly assessed the fly-killing power of each retrieved PTS by exposing 10 AMF to the sphere. Each PTS was tested twice: soon after return from the field (with no supplemental feeding stimulant applied to the sphere), and again after application of a 20% sucrose solution to stimulate fly feeding. Residence time on spheres and condition (alive or dead) at 72 hours post-exposure were recorded for each fly.

Results

Treatment Effectiveness. As indicated by captures of AMF on unbaited monitoring spheres on interior trees of each plot, the numbers of AMF that penetrated into plots surrounded by wooden PTS were substantially fewer (~ 30% fewer) than the numbers that penetrated into plots surrounded by sugar/flour PTS or sticky spheres and were only about 3% greater than the number that penetrated into insecticide-treated plots (Table 1). Very few sampled fruit were injured by AMF in plots surrounded by wooden PTS (0.13%) or sticky spheres (0.13%) or in plots sprayed with insecticide (0.17%), whereas a greater percentage was injured in plots surrounded by sugar/flour spheres (0.58%) (Table 1).

Structural Integrity. Data in Table 2 show that after 6 weeks of field exposure from early July until mid-August, 37% of sugar/flour PTS but only 10% of sugar/wax discs atop wooden PTS had lost 20% or more of their surface area to feeding by rodents or other mammals. All of the feeding on sugar/wax discs occurred in a single orchard and was perpetrated by raccoons, which were observed to be numerous in that orchard. All sugar/flour PTS and all discs atop wooden PTS were replaced at mid-August. By mid-September (4 weeks later), 47% of sugar/flour PTS but 0% of discs atop wooden PTS had lost 20% or more of their surface area due to feeding by vertebrates.

Residual Sugar. As depicted in Figure 1, the amount of sugar remaining in sugar/wax discs atop wooden

Table 1. Captures of feral AMF on unbaited monitoring traps and percent injury to fruit by AMF in 24 plots of apple trees in six commercial orchards in 2001.

Treatment*	No. AMF captured per plot**	Fruit injury per plot (%)***
Wooden PTS	38.1	0.13
Sugar/flour PTS	54.5	0.58
Sticky Spheres	53.0	0.13
Insecticide Sprays	36.9	0.17

* Within columns, differences among treatments were nonsignificant at odds of 19 to 1.

** Based on four unbaited spheres per plot.

*** Based on 100 fruit sampled per plot on each of five bi-weekly sampling dates from July to September.

Table 2. Percentage of sugar/wax discs atop wooden PTS and percentage of sugar/flour PTS having greater than 20% estimated damage by feeding of rodents or other mammals, based on visual inspection (bi-weekly) of 120 discs or spheres.

	Spheres damaged by feeding (%)*	
Weeks of field exposure	Discs atop wooden PTS	Sugar/flour PTS
2	9	16
4	10	28
6	10	37
All sugar/wax discs and all sugar/flour spheres were replaced at mid-season (after week 6)		
2	0	46
4	0	47

* Loss of 20% or more of mass (discs) or surface area (sugar/flour PTS).

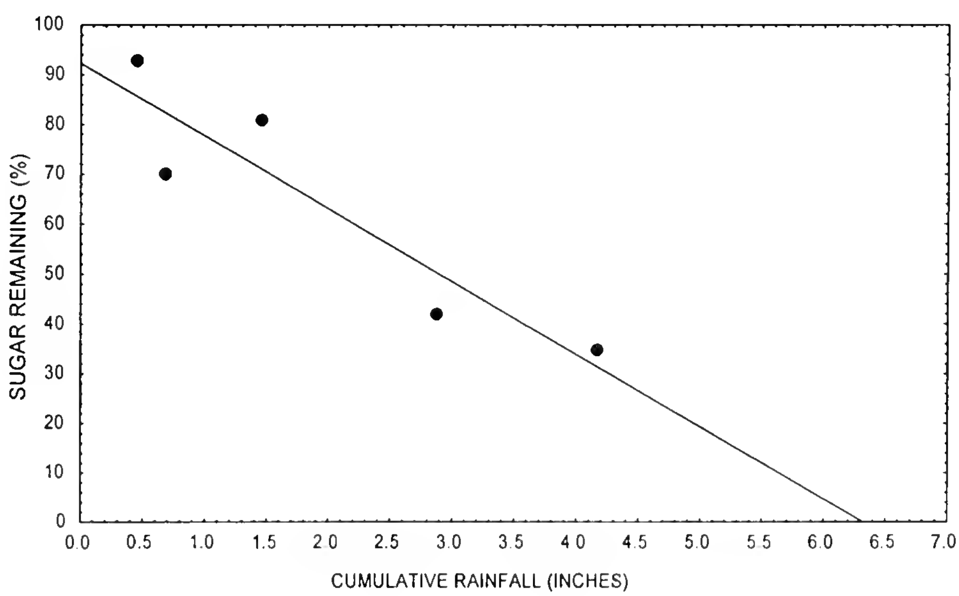

Figure 1. Visually estimated percent of original sugar remaining in sugar/wax discs atop wooden PTS after exposure to rainfall in commercial apple orchards. Visual estimates were based on color of discs, which range from red (no sugar loss) to white (complete sugar loss).

PTS (as assessed by color of discs) declined in concert with the amount of rainfall to which discs were subjected during their 6-week exposure period in commercial orchards. The relationship between amount of remaining sugar and amount of rainfall appears to be approximately linear and suggests that very little sugar would remain after 6 inches of rainfall. Besides rainfall, droplets of dew accumulating in reservoirs of sugar/wax discs also result in release of sugar onto the surface of wooden PTS. This is advantageous to sphere performance during periods of dry weather.

Residual Toxicity. After the first 6 weeks of field exposure under 4.17 inches (on average) of cumulative rainfall, wooden PTS killed 37% of alighting AMF compared with 69% kill of alighting AMF by sugar/flour PTS (Table 3).

After 12 weeks of field exposure of wooden PTS (accompanied by replacement of sugar/wax discs at 6 weeks), 39% of alighting AMF died (Table 4). Total rainfall averaged 3.14 inches during weeks 7-12 and 7.31 inches over the entire 12 weeks of sphere exposure. In addition to 39% mortality of alighting AMF, another 14% of AMF, though alive, were unable to fly 72 hours after contact with wooden PTS. When a 20% sugar solution was applied to 12-week-

Table 3. Mortality of AMF after exposure to PTS. All evaluated PTS were placed in commercial orchards during the first week of July and retrieved after 3 or 6 weeks of field exposure. AMF were exposed individually to each PTS and allowed to forage freely on it for up to 10 minutes.

Weeks of PTS orchard exposure	Average amount of rainfall (inches) per orchard during each interval	AMF mortality (%) 72 hours after exposure*		
		Wooden PTS	Sugar/flour PTS	Spheres without insecticide
3	2.02	38	72	0
6	2.15	37	69	2

* Each value is based on sphere exposure to 120 AMF (10 AMF per sphere x 2 spheres per orchard x 6 orchards).

Table 4. Mortality of AMF after exposure to PTS. All evaluated PTS were retrieved from commercial orchards at the end of the season: for wooden PTS, 12 weeks of field exposure after deployment in early July accompanied by replacement of sugar/wax discs in mid-August; for sugar/flour PTS, 6 weeks of field exposure after deployment in mid-August. AMF were exposed individually to each PTS and allowed to forage freely on it for up to 10 minutes.

Weeks of PTS orchard exposure	Average amount of rainfall (inches) per orchard during each interval	AMF mortality (%) 72 hours after exposure*		
		Wooden PTS	Sugar/flour PTS	Spheres without insecticide
9	0.56	68	-	2
12	2.58	39	-	3
12**	-	100	-	0
3	0.56	-	77	3
6	2.58	-	58	2
6**	-	-	87	0

* Each value is based on sphere exposure to 120 AMF (10 AMF per sphere x 2 spheres per orchard x 6 orchards).
** 20% sugar solution applied to sphere surface prior to fly exposure.

exposed wooden PTS, 100% of AMF died (Table 4). This result indicates that the 4% (a.i.) amount of imidacloprid in latex paint on the surface of wooden PTS remained highly effective in killing AMF after 12 weeks of exposure to sunlight and 7.31 inches of rainfall.

After 6 weeks of field exposure from mid-August until late-September, sugar/flour PTS that were deployed in mid-August killed 58% of alighting AMF (Table 4). When a 20% sugar solution was applied to these spheres, 87% of AMF died (Table 4).

Conclusions

Populations of AMF were substantially greater in 2001 than in 2000 in commercial apple orchards in Massachusetts. In 2000, wooden PTS topped by fluted-type sugar/wax discs were slightly superior to sugar/flour PTS in controlling AMF in commercial orchards. In 2001, as described here, wooden PTS topped by reservoir-type sugar/wax discs were substantially better in preventing AMF penetration of commercial orchard blocks and preventing injury to fruit than were sugar/flour PTS. Indeed, wooden PTS were just as effective as 2-3 sprays of insecticide in providing effective AMF control in 2001.

In 2001, sugar/flour PTS experienced about the same level of damage by rodents and other mammals as they did in 2000: 35-47% of sugar/flour PTS received 20% or more damage by such vertebrates after 6 weeks of orchard exposure. Even though our residual toxicity tests suggest that intact sugar/flour PTS killed at least 58-69% of alighting AMF during 6 weeks of orchard deployment, the fact that more than a third of such spheres were not substantially intact by the end of 6 weeks probably accounts for the lesser degree of AMF control provided by sugar/flour PTS.

In 2000, 20-31% of sugar/wax discs atop wooden PTS experienced 20% or more damage by vertebrates after 6 weeks of field exposure. In 2001, only 0-11% of our new-version discs (protected by embedded wire) experienced 20% or more damage by vertebrates after a similar amount of field exposure, and all of the observed damage was caused by raccoons in a single orchard. No damage occurred from rodents. The level of kill of alighting AMF by wooden PTS (37-39%) after 6 weeks of sugar/wax disc exposure, coupled with an average of 14% of survivors that were unable to fly, gave rise to 51-53% incapacitated AMF that alighted on wooden PTS. This level was less than the kill afforded by intact sugar/flour PTS (58-69%), but apparently was sufficiently great to have provided excellent protection of fruit against injury by AMF.

For the future, we plan to focus on optimizing the size of sugar/wax discs atop wooden PTS so that a single disc might provide a sufficient supply of sugar to the sphere surface to last for the entire 12-week season of AMF activity in commercial orchards. We know from 2001 results reported here that the 4% a.i. level of imidacloprid in latex paint on the surface of a wooden PTS is sufficient to kill all alighting AMF, even after 12 weeks of orchard exposure. We also know from results reported here that little or no sugar is likely to remain in sugar/wax discs atop wooden PTS after about 6 inches of rainfall. Our challenge thus lies not in preserving the residual activity of insecticide, but in ensuring a residue of sugar on wooden PTS.

Acknowledgements

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* * * * *

Residual Activity of Insecticide on Wooden and Plastic Pesticide-treated Spheres

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To date, all tests of pesticide-treated spheres (PTS) for control of apple maggot flies (AMF) in commercial apple orchards in Massachusetts have been conducted using spheres made of solid wood. As of spring 2001, wooden spheres in the form in which they have been purchased and sold by commercial pest management supply companies for the past three decades (rejected croquet balls) no longer are manufactured. Hence, if PTS capped by discs of sugar and wax are to remain viable as a potential means of controlling AMF (see preceding article) then an alternative to wooden PTS must be found. For several years, Great Lakes IPM of Vestaburg, Michigan has been producing and marketing durable hollow plastic spheres for coating with Tangletrap and use in monitoring populations of AMF. Such plastic spheres (or a similar type) are the most likely spheres to be used for future control of AMF by sugar-capped PTS.

Here, we report on studies conducted in 2001 evaluating the residual activity of insecticide in paint applied to wooden and plastic spheres.

Materials & Methods

Wooden spheres were the same 3.25-inch diameter spheres that we have had on hand and have been using for several years in our studies on sugar-capped PTS. Plastic spheres were 3.5 inches in diameter and purchased from Great Lakes IPM (marketed as "reusable red ball traps"). Before painting, plastic spheres were shaken in a container of sand to roughen the surface. Preliminary testing showed that paint containing insecticide tended to chip off of non-roughened plastic spheres. In addition to clean-surface wooden spheres and roughened-surface plastic spheres, we also evaluated wooden spheres that had been treated in 2000 with a coating of latex paint containing 2% (a.i.) imidacloprid (Provado) and exposed for 12 weeks in commercial orchards in 2000. These spheres were not cleaned before application of paint and insecticide in 2001. Rather, they were partially covered with sooty mold that grew on sugar on the sphere surface during field exposure in 2000.

All spheres received a single coating of black latex paint containing 4% (a.i.) imidacloprid (Provado) before deployment. The only exception was control spheres, which received paint but no insecticide. Half of the pesticide-treated wooden and plastic spheres received 20% sugar (sucrose) in the mixture applied to the sphere surface. The remaining half received no sugar in the paint. Addition of sugar to the paint mixture assures presence of sugar on the sphere surface at the time of sphere deployment, but could result in a tendency of paint to deteriorate or chip off during field exposure.

In early July, all spheres were hung from branches of apple trees in an unsprayed section of the Horticultural Research Center in Belchertown. Spheres remained in place for 12 weeks, when they were returned to the lab for evaluation of residual toxicity of insecticide. For this, we applied a 20% sucrose solution to the surface of each sphere to stimulate fly feeding and then exposed 10 AMF individually to two spheres of each type. Flies were allowed to remain on a sphere for up to 10 minutes, after which they were transferred to clean cups with food and water. Mortality was measured at 72 hours.

Results

Data presented in Table 1 show that 90-100% of AMF exposed to each type of wooden or plastic PTS

Table 1. Mortality of AMF after exposure to wooden or plastic PTS. All PTS were exposed on unsprayed apple trees for 12 weeks before testing.

Sphere	Sphere surface clean when paint applied	Paint contained 20% sucrose when applied	AMF mortality (%) 72 hours after exposure
Wooden	Yes	No	100
Wooden	Yes	Yes	100
Wooden	No*	Yes	90
Plastic	Yes	No	90
Plastic	Yes	Yes	100
Control	Yes	No	0

* Uncleaned spheres used in commercial orchards in 2000.

died as a consequence of feeding on the sphere surface. During the 12-week period of field exposure, 10.7 inches of rain fell on the spheres.

Conclusions

Our findings indicate that latex paint containing 4% (a.i.) imidacloprid applied to plastic spheres (after roughening of the sphere surface) conferred an amount of residual toxicity to AMF essentially equal to that of the same mixture applied to wooden spheres, and did so after 12 weeks of field exposure to 10.7 inches of rainfall. Our findings also indicate that addition of 20% sucrose to the paint-pesticide mixture did not detectably affect residual activity of paint or pesticide. Finally, we found that it is not necessary to clean spheres prior to repainting with latex paint and insecticide in order to obtain a high level of mortality of alighting AMF.

Together, these findings pave the way for substitution of durable plastic spheres for wooden spheres in the pursuit of effective PTS for controlling AMF.

Acknowledgement

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Do Sugar Caps Atop Wooden Pesticide-treated Spheres Affect Apple Maggot Fly Attraction to Spheres?

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In three preceding articles in this issue of Fruit Notes, we have shown that wooden or plastic pesticide-treated spheres (PTS) topped by sugar/wax discs that release a continual supply of sugar onto the sphere surface hold much promise for directly controlling apple maggot flies (AMF). More specifically, we found that discs of 2-inches diameter x ¾-inch height (weighing 50 grams) contain and release enough sugar to endure up to about 6 inches of rainfall and/or 6 weeks of orchard exposure before the supply of sugar is spent. Ideally, to be cost-effective and appealing to growers for use in controlling AMF, discs ought to contain enough sugar to supply a sphere for the entire 12 weeks of the AMF season and do so under 12 inches or more of rainfall. This can be accomplished by increasing the size of the disc to some upper limit beyond which the shape of a sphere is sufficiently altered so as to become less attractive to AMF.

Here, we report results of a field test conducted in 2001 evaluating the impact on attractiveness to AMF of different sizes of discs atop plastic PTS.

Materials & Methods

All spheres were 3.5 inches in diameter, red in color, made of durable plastic and purchased from Great Lakes IPM of Vestaburg, Michigan. All discs were cut out from pink styrofoam insulation panels. The pink color of these discs was equivalent to initially red sugar/wax top caps that had lost about one-third of their sugar content under about 2 inches of rainfall. The size of discs ranged from 1.5-inches diameter x ¾-inch tall to 3-inches diameter x 1.5-inches tall. All discs were centered atop plastic PTS (Figure 1). The entire surface of each sphere (but not the disc) was coated with Tangletrap to capture alighting AMF.

Spheres were hung from branches of fruiting Delicious trees (M.26 rootstock) in an unsprayed block of apple trees at the Horticultural Research Center in Belchertown on July 31. Each of the 72 fruiting trees contained a single sphere. For each replicate, there were nine treatments consisting of eight sizes of discs plus a control sphere without any disc. Each of these nine

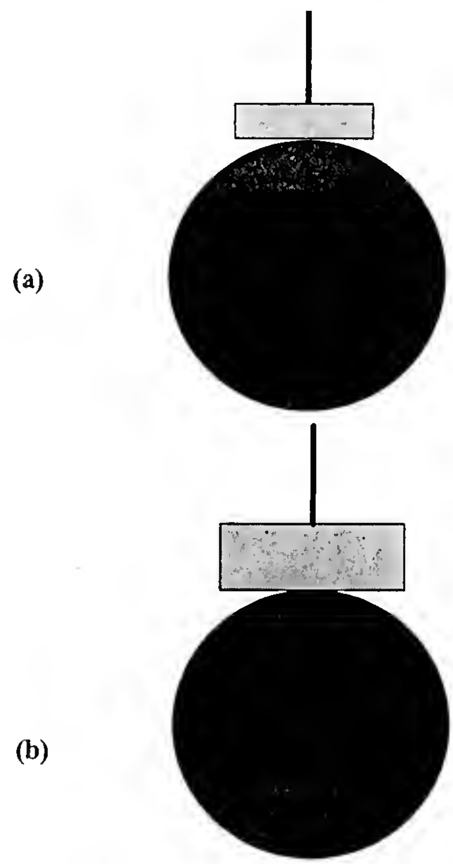

Figure 1. Schematic illustration of a 3.5-inch sphere topped by a disc of (a) 1.5-inches diameter x ¾-inch tall or (b) 3-inches diameter x 1.5-inches tall.

treatments was replicated eight times. Every two weeks until September 11, captured AMF and other insects were removed from spheres and treatments were rotated to different trees within the block of 72 trees. Besides counting the number of AMF on a sphere, we also recorded the location of each captured AMF according to top half or bottom half of the sphere.

Results

In a preliminary test involving 16 replicates, we found no difference in the number of AMF captured by spheres without a disc (1.1 AMF per sphere) and spheres topped with a disc of 1.5-inches diameter x ¾-inch tall (1.1 AMF per sphere). This allowed us to substitute spheres without discs for spheres topped by discs of 1.5-inches diameter x ¾-inch tall in our experimental protocol and hence distribute eight replicates of nine

Table 1. Capture of AMF on red plastic spheres (3.5-inches diameter) topped by pink styrofoam discs of different sizes.

Size of disc (in)		No. AMF captured per sphere*		
Diameter	Height	Top half	Bottom half	Total
No disc	-	3.8	4.4	8.2
1.5	1.2	3.1	5.5	8.6
1.5	1.5	4.0	4.1	8.1
2.4	0.75	7.1	8.1	15.2
2.4	1.2	6.3	6.9	13.2
2.4	1.5	5.5	6.6	12.1
3.0	0.75	4.0	6.4	10.4
3.0	1.2	5.6	8.6	14.2
3.0	1.5	4.5	7.0	11.5

* There were no significant differences among treatments in total captures of AMF at odds of 19 to 1.

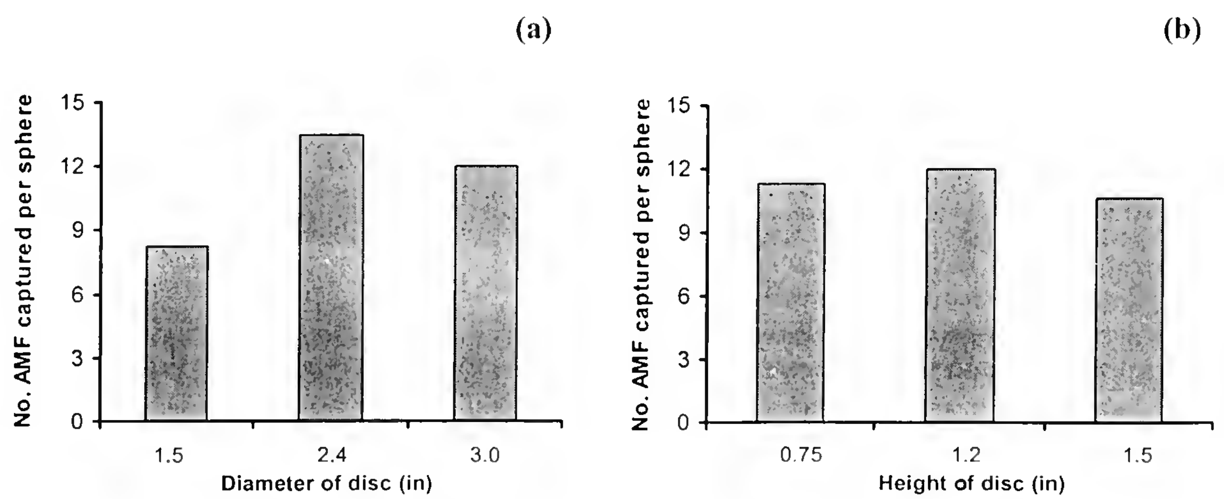

Figure 2. Capture of AMF on spheres topped by (a) discs of different diameters (averaged across discs of different height) or (b) discs of different heights (averaged across discs of different diameters).

treatments among the available 72 fruiting trees.

Although there were no significant differences among spheres topped by different sizes of discs in total AMF captured, data in Table 1 are suggestive of some trends. The three types of spheres capturing the fewest AMF were control spheres without discs and spheres topped by discs of 1.5-inches diameter. As a group, these spheres captured only 60% as many total AMF as spheres topped by discs of 2.4-inches diameter and only 67% as many total AMF as spheres topped by discs of 3-inches diameter (Figure 2). Also, as a group, spheres topped by discs of 1.2-inches height captured about 6% and 14% more total AMF than spheres topped by discs of ¾-inch and 1.5-inch height, respectively (Figure 2).

With respect to capture of AMF on the top half versus the bottom half of spheres, data in Table 1 show the following: for spheres having discs of ¾-inch, 1.5-inch, and 3-inch diameter: 55, 53, and 62%, respectively, of all captured AMF were found on the bottom half of spheres.

Conclusions

To our pleasant surprise, spheres topped by discs of 2.4 or 3 inches in diameter caught more total AMF than spheres without discs or spheres topped by discs of 1.5-inch diameter. Height of disc had little effect on fly captures. Somewhat more AMF were captured on the bottom half than the top half of spheres.

Together, these findings bode well for future use of sugar/wax discs that are larger than the 2-inch diameter x ¾-inch tall discs we used in our 2001 laboratory and field tests. It appears that we could increase the size of sugar/wax discs to 3 inches in diameter x 1.2 or 1.5 inches in height and by doing so actually enhance sphere attractiveness to AMF. Furthermore, our findings here that most AMF alight on the bottom half of spheres suggest that post-alighting AMF would have increased probability of encountering sugar on the sphere surface, which tends to collect more on the bottom half of spheres. Finally, information from another test revealed that all 50 AMF observed alighting on spheres topped by sugar/wax discs (2-inches diameter x ¾-inch tall) did so on the spheres themselves and not on the discs. This ensures that alighting AMF would encounter pesticide and sugar on the sphere surface rather than pesticide-free sugar discs atop spheres.

Acknowledgements

We thank Jaime Pinero and Sara Dynok for assistance. This study was supported by grants from the USDA CSREES Pest Management Alternatives Program and Crops at Risk Program.

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Private Property Rights A Look at Its History and Future

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Private property rights is a sore subject for many landowners, especially among those who have owned land for a generation or more. In fact, the perception of sovereignty is a function of tenure: the longer land has been owned by a family, the stronger its ties to the land, and the more threatened the family becomes when someone brings up the subject of rights. Yet, the history of private property in the U.S. is fascinating, and our view in this country of an individual's rights is far more liberal than in most other countries (I use the term "liberal" in the context of interpretation, not in the context of "liberal" versus "conservative"). In many European countries, for instance, an individual can own land and can benefit from it, but his ability to make decisions about how the land is used is limited, far more so than here in the U.S. In China (and most other third-world countries around the world), there is no such thing as private real property. An individual can own crops and trees, but the land is publicly owned. Virtually the entire population of the world lives on land it does not own, but in our country, such is not the case. Americans enjoy real property rights that are far more generous when compared to the rest of the world. So, why then is it such a sore subject?

Thomas Jefferson is largely credited with espousing sovereignty for private property in the U.S. when he said more than 200 years ago: "Nothing is ours, which another may deprive us of." Property-rights advocates argue that Jefferson's words are as true today as then. However, most of us forget that he lived during a time when the colonists were telling the King of England to mind his own business. Then, a lack of sovereignty meant subjugation, and the ownership of property by all men was tangible proof that the American people no longer answered to the King. To own land and make it productive, according to Jefferson, is the right of every American.

The colonists of the mid-18th century, virtually all of whom were second and third generations of the original emigrants, were unwilling to be bridled by the King who offered few services in exchange for taxes. The Revolutionary War was about land, to a great degree: does the King say who goes where, or do local people make those decisions? When the dust settled, the colonists had severed ties with the monarchy, but the legal system under which property rights were defined–an enduring legacy of the King of England–mostly stayed with us.

For almost 100 years following the War for Independence, virtually every debate in Congress was about land and property rights, but little was changed in terms of the interpretation of rights. During this period, land was about the only valuable asset available to the U.S., and Congress used this asset as its currency. For example, a Vermonter by the name of Justin Morrill convinced Congress in 1862 to create a nationwide system of universities, funded not with cash, but with land. Known even today as the "land-grant universities," virtually all of the state colleges (or at least one in each state) got their first major appropriation in land.

So prevalent were land grants among Americans that for a period during the first hundred years following the Revolution, land grants were a more common form of currency than gold or paper money. A land grant, written on parchment, frequently folded and dog-eared might change hands to settle a debt many times before landing in the possession of a farmer who filed a claim for title and actually took ownership of th eland. Once claimed, the title to land

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guaranteed that farmer essentially the same rights available to a pre-war colonist. To this day, our interpretation of private real property rights, based on English common law, is little changed.

The one essential difference between property law in England 200 years ago and the American Colonists' application of the laws was that a colonist was not bound by primogeniture, a hold-over rule from feudal law that restricted transfers of ownership. Under the concept of primogeniture, the entire real estate of an English landlord passed to only one heir: his first-born son, or to the closest consanguine male (father, brother, uncle, cousin, and so on). It was not uncommon for an eldest daughter to see her father's lands inherited by a late-born, five-year-old brother; or if her father never sired any sons, the land might go to her uncle. If the uncle predeceased her father, the estate might end up in the hands of a male cousin.

Primogeniture evolved in feudal times as a way for the King's lands to pass within families of nobility, but since the King was under no obligation to share his interests, the lords had no rights to divide the estates entrusted to them. The concept survived evolution from feudal law, because it prevented fragmentation of productive lands and also maintained a relatively easy method of gathering taxes. It did not survive in the American colonies, because the emigrants to the new world were mostly families of expatriates–children forced to leave their homelands because only one of their ranks could inherit the family wealth. Given the circumstances, it is unsurprising that primogeniture was left behind and the colonists embraced the rights to transfer ownership to whomever the current owner wished.

Real property differs from other personal property in the sense that it is immobile, so the acquisition of land is really the acquisition of rights. The sum of these rights today, also known as the "bundle of rights," define a person's interests in land. These include the following: the rights of use, occupancy, cultivation, and exploration; the rights to minerals (including the right to extract them); the rights to sell or assign interests in land (such as in the case of selling timber); the rights to license or lease; the rights to develop, to devise, and inherit; the rights to dedicate, give away, and share; the rights to mortgage and exercise a lien; and the rights to trade or exchange land. Notwithstanding this list of rights, our interpretation of the bundle of rights is intended to be inclusive. That is to say, even rights that are not specifically described, such as the right to pick berries, is implicit. However–and this is a key point, the very substance of the debate about private real property rights–the exercise of the bundle of rights is subject to limitations the state may impose for the sake of protecting the public's interests. Private property rights are not absolute. In the U.S., public authorities have reserved essentially the same rights as those originally reserved by the King.

In exchange for the state's willingness to defend an owner's property, it reserves interests in those lands, including the right to tax land; the right to take land for public use with just compensation (also known as "eminent domain"–sort of sounds like the King talking, doesn't it?); the right to control use to ensure protection of the public's interests; and–when an owner dies without a will and no known legal heirs–the right of escheat, i.e. to take possession of the land.

In the U.S., states also own wildlife that inhabits private lands, much as the King reserved the rights to wildlife on lands of his kingdom. A landowner can harvest wildlife but only with a proper license from the state and during the appropriate season. Rules about game licenses vary by state, but the point is that no one but the state owns wild animals until they have been harvested.

It is not too surprising that most of the debate about private property rights is on deciding when the public's interests are at stake, what constitutes a "taking" or rights, and how to figure "just" compensation. For example, does a landowner have the right to install a hazardous-waste processing facility? Probably not, but the answer depends on the extent to which the public is protected from any negative impacts that might result from this decision. If the answer is no, does this constitute a "taking " of the owner's rights? And if so, what is "just " compensation for denying these rights?

More likely, the situation is reversed: the state offers to buy land for such a facility. If the owner refuses to sell, the state condemns the current uses of the land and exercises its right of eminent domain (in the name of public welfare, of course). What is just compensation for a taking in this instance? Not what you would expect. Most often, compensation is limited to reimbursing the owner for the value (and future value) of the land's current use. If it is hay land with a beautiful view, just compensation covers the value of the land for hay, not the potential loss from

selling the land as a future homesite.

Federal, state, and local laws can change the way people use their lands, but most often these statutes are intended to protect current uses while avoiding property conversions that might prove costly for the community in the future. It is ironic that many of the people who complain the loudest about erosion of private property rights are the ones who invariably want to retain the option of selling out to the highest bidder, for whatever use, and regardless of the cost to others in the community. Converting productive farm and forest lands to non-agricultural uses at a rate that threatens the very fabric which supports productive lands would have seemed suicidal to Thomas Jefferson, whom–I'm guessing if he were here to see it–would have been tempted to say: "We have nothing if we deprive ourselves."

* * * * *

Regulating Fruit Set and Maturity of Macoun Apples

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The objective of this study was to compare the efficacy of two chemical thinning treatments: Accel plus carbaryl, or NAA plus carbaryl, with an untreated control. A second objective was to evaluate the efficacy of ReTain for delaying Macoun fruit maturity and to determine if there was an interaction between ReTain and thinning treatment on fruit characteristics at harvest.

Both thinning treatments were effective in reducing fruit set in 1997 (Table 1). Accel plus carbaryl was effective again in 1998, while NAA plus carbaryl over-thinned (Table 2). Accel increased fruit size in 1997, compared to unthinned controls (Table 1), and both thinning treatments increased fruit size in 1998 (Table 2). Accel increased fruit firmness in both years (Table 3). ReTain reduced preharvest drop and delayed fruit maturity both years. In 1997, firmness was greatest for fruit treated with Accel and ReTain, while ReTain had no effect on fruit firmness in 1998. Accel + Sevin increased return bloom compared to NAA + Sevin in 1998 (Table 4).

Table 1. Macoun fruit set and size, 1997.[z]

Treatment	Fruit set (%)	Fruit wet (no. fruit/cm^2 limb cross-sectional area)	Fruit weight (g)
Control	66 a	10.0 a	150 b
NAA + Sevin	29 b	6.3 b	150 b
Accel + Sevin	33 b	5.1 b	166 a

[z] Means in columns significantly different at odds of 19 to 1 if not followed by the same letter.

Table 2. Macoun fruit set and size, 1998.[z]

Treatment	Fruit set (%)	Fruit wet (no. fruit/cm^2 limb cross-sectional area)	Fruit weight (g)
Control	55 a	6.5 a	139 b
NAA + Sevin	20 b	1.4 c	179 a
Accel + Sevin	30 b	3.6 b	177 a

[z] Means in columns significantly different at odds of 19 to 1 if not followed by the same letter.

This study was done at Chick Orchards, Inc., Monmouth, ME with the assistance of the management and employees of Chick Orchards, Inc. Also, Dr. Schupp was with the University of Maine at the time of the study.

Table 3. Effect of Accel and ReTain on fruit firmness of Macoun apples in Maine.[z]

Treatment	Fruit firmness (lb) 1997	1998
Accel + ReTain	18.6 a	18.3 a
Accel alone	17.9 b	18.0 a
NAA + ReTain	17.2 c	17.4 b
NAA alone	17.3 c	17.2 b

[z] Means in columns significantly different at odds of 19 to 1 if not followed by the same letter.

Table 4. Effect of NAA or Accel on return bloom of Macoun, May, 1998.

Treatment	Return bloom (no. flower cluslter/cm^2 limb cross-sectional area)
Control	10.9
NAA + Sevin	11.8
Accel + Sevin	14.7

* * * * *

Improving the Growth of Newly Planted Apple Trees

Dr. James R. Schupp
Hudson Valley Laboratory, Cornell University

The objective of this study was to compare the effects of pre-plant mono-ammonium phosphate (MAP), with or without broadcast apple pomace compost, on the early growth and fruiting on apple trees.

Macoun/B.9 apple trees were planted using a tractor-mounted tree planter on May 1, 1998 into plots which had received one of the following combinations of pre-plant treatments: 1) no compost plus urea; 2) no compost plus MAP; 3) compost plus urea; and 4) compost plus MAP.

First-year Results

Compost application increased soil pH and cation exchange capacity (CEC) of the plots (Table 1). Soil P, K, Mg, and Ca also were increased in compost plots. Pre-plant MAP had no effect upon soil pH, CEC, P, K,

Table 1. Effect of apple compost on orchard soil properties, 1998.

Treatment	Soil pH	Cation exchange capacity	K (lb/A)	Mg (lb/A)	Ca (lb/A)
Control	6.4	6.9	279	296	2582
Compost	6.9	10.8	645	476	2701
Significance	**	***	***	**	***

Table 2. Effect of apple compost on leaf macro-nutrient concentrations, 1998.

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
Control	2.64	0.18	1.42	0.81	0.35
Compost	2.85	0.19	2.07	0.80	0.31
Significance	**	NS	***	NS	*

This project was supported in part by a grant from the New England Tree Fruit Growers Research Committee. Also, Dr. Schupp was with the University of Maine at the time of the study.

Table 3. Effect of compost and MAP on new tree growth, 1998.

Treatment	Trunk cross-sectional area increase (cm^2)	Total shoot length (cm)
Urea only	1.0	106
MAP only	2.1	113
Compost + Urea	2.8	125
Compost + MAP	3.4	125
Significance:		
Compost	***	*
MAP	*	NS
Compost x MAP	NS	NS

Mg, or Ca (data not presented).

Apple compost increased N, K, and Mg in leaves (Table 2). Pre-plant MAP had no effect upon leaf mineral nutrient concentrations (data not presented).

Both compost and MAP increased trunk growth in 1998 (Table 3). Compost also increased the total shoot length per tree.

In summary, the addition of organic matter in the form of apple compost increased the growth of newly planted apple trees, by increasing nutrient holding capacity and water holding capacity of the soil. The effects were small (i.e., 14% more shoot growth) in the first season, and it remains to be seen if growth of the trees in composted plots continue to be superior. Pre-plant incorporation of MAP also increased first-year tree growth, although not to the same extent as compost. The reason for this improved growth is not explained by the data. Leaf N and P concentrations were not affected by MAP, nor was soil pH.

Sorting Out the Family From the Business

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There is a German saying referring to family business. It goes like this: "The first generation struggles to build it from scratch. The second generation improves it and expands it. The third generation spends it."

Although this saying does not apply to all family businesses, there is a lot of truth to it. Many families struggle to overcome these tendencies. Many businesses get in trouble over family issues. At the same time, both family and business can benefit from working and growing together.

Understanding different perspectives of your family business can help you avoid the potholes on the way and contribute to making the best out of the opportunities ahead.

Three Perspectives

Of course there are a lot of different ways to look at family business. Three perspectives are key to meeting the challenges of family enterprises: business, ownership, and family (Figure 1). Family businesses differ in how they are organized around these three perspectives. Although they overlap, they should be viewed as separate subsystems.

Persons involved in your family business, whether family or employee, can be looked at from the ownership, the business or the family perspective. The diagram shows where different people are in relation to each perspective. Everybody who is family is in circle 1. Everybody who is working in or for the business is in circle 2. Everybody who is a shareholder is in circle 3. If everyone in your family business would be part of only one circle, then the tree circles would not overlap. But then we would not be talking about family business--that's what's special about family businesses: people involved in the business are part of different circles.

Some of your employees might only be part of the business cycle (sector 2). Some of your family members might only be part of the family cycle (sector 1). It helps to guide you and them in finding the right decision if you spend some time clarifying that their involvement and contributions will be different from those of others who are involved in more than one way.

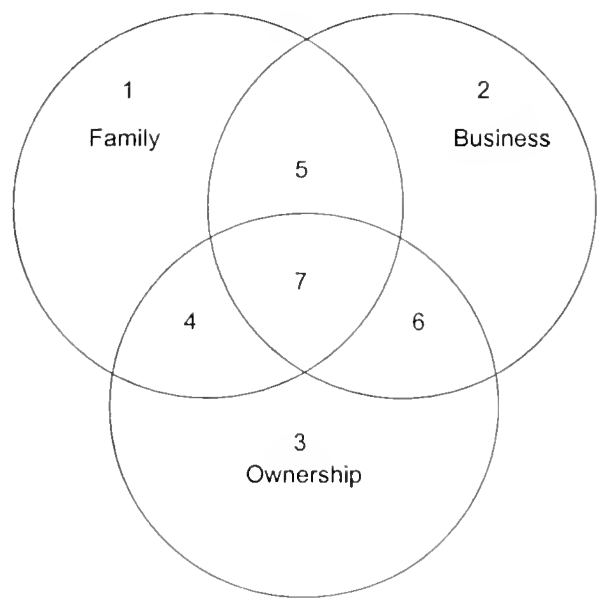

Figure 1. Three perspectives of family business (adapted from Gersick et al.).

For example, an employee cannot be expected to work as hard in the enterprise as somebody who is also an owner and a family member (sector 7). If you need your employees to work 150% for some time or if overtime is necessary, you have to provide incentives for them to do so. Actually, there are business owners who give their most important employees access to shares of the enterprise to overcome this problem. Employee owners belong to sector 6 of the diagram.

On the other hand, family members, who are not part of the business or owners, might not understand how you can spend so much of your quality time working on business issues. Family crisis might be caused by not being clear about the different levels of involvement and the consequences thereof. The classical in-law scenario is based on this conflict: a son or daughter not yet owner of the parent's business is spending every weekend working there, not to speak of the rest of the week, the long hours, and the number of times he or she misses the common dinner or the long awaited theater evening. The outside working spouse will not tolerate this situation forever.

Conflicts are Unavoidable

Potential conflicts can be eluded or solved more easily when you clarify everybody's position in the overlapping circles. Take two brothers who have inherited the business from their deceased father. One has never worked there but is an owner now. He is in sector 4. His brother is the manager and also owner. He is sector 7. The non-employee brother wants to get some dividend out of his ownership. The managing brother wants to invest in new state-of-the art equipment. Both had difficulties understanding why it was so hard for them to agree on the right course of action, because they had always been very close. Seeing the rationale behind their different interests made it easier for them to find a solution that did not hurt their relationship.

Family and Employees

Another area of challenges for family business is sector 5, the overlap between family and business. Facing the decision about which family members should work in the enterprise and which will do better somewhere else, can be a very difficult situation for the business family. Employee owners (sector 6) can be rather resentful about family members being drawn into a business with what they perceive as minor qualifications. They like to see the best person hired for the job. They are afraid of someone coming in with special privileges but without special skills.

On the other hand, for many families it is part of their culture and philosophy as a business family to have as many family members as possible working together in the same enterprise. One of the benefits of all the hard work in a family business is the chance to work together as a team with the people you trust and love. Sons and daughters growing up involved in the business are not just other employees. Ideally, they have been part of the business and contributed since an early age. They know the ropes from youth and have learned the trade very thoroughly, in a way that can hardly be achieved by someone from the outside.

Certainly, the ideal is not always realized, and sometimes the employees' fears of another family member stirring things up are well grounded. Therefore, if you want your children to grow up to become employees, managers, and at some point owners of your business, you will have to prepare for this early on. Start letting them share what is going on at an early age. Let them participate in decision making at the level they are at. If you keep the right to make final decisions until the very end, they will not grow up to be the managers and owners you want them to be.

Family business succession is a long-term project. It starts when the family is still young and might not even be in control themselves. With their parents planning to hand over control to them, they might already begin to share it with their own youngsters. This is a difficult step to take.

For the sake of the family, the employee, and the business, aspire to define everybody's role in the family business. As long as the family member is an employee, the "chain of command" has to apply to him or her, the same as to other employees. The wages have to be fair depending on work done. No extra dollars for family membership. If someone in the family needs more money, look for other ways to do this: a loan, dividends based on ownership, or a different higher paying job. However, it can hurt your business to base promotion on family membership. You might lose your best employees if they feel they will not be promoted or they are doing the less interesting jobs because there is always someone

outranking them.

High benefits, high challenges, hard work and great fun are the different aspects of a family business. Meeting the challenges and having fun together after hard work is very rewarding. People and businesses change over time, and new challenges are just around the corner. But different generations working and growing together, is a way of life.

Clarifying Interests

Sometimes family and business issues get mixed up, and ongoing misunderstandings have led to deep wounds that prohibit the family and the business from prospering. In these cases, an outside mediator can support the family. If the main issues are related to the business, a consultant might be the best choice. But where the problem exactly lies is hardly visible to those involved when the tensions are high. A close friend or business associate may be able to help you in sorting out the issues and deciding how to proceed. The use of some management tools can prevent unnecessary tension by spelling out the position that everybody is in.

Each person involved can live up to his or her potential and develop his or her role, in the business, in the family or as an owner, more easily once the situation is clarified.

Interests coming from the different perspectives will be obvious to anyone involved. Developing joint decisions will become less painful. Solutions can be found more easily. Possible conflicts may even be avoided. Clarifying where everybody stands will contribute to smoother relationships and better business decisions.

Reading tips: Gersick, K.E. Davis J.A. Hampton, M. M. Lansberg, I.. (1997): Generations to Gernations: Life Cycles of the Family Business. Harvard Business School Press, Boston (Massachusetts) ISBN 0-87584-555-X

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Rootstock Effects on Ginger Gold Apple Trees

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On of the most critical decisions when establishing an apple orchard block is the selection of rootstock. Rootstock can affect tree size, yield per tree, and fruit quality. Improper understanding of how a rootstock affects these characteristics can result in an inefficient or even unsuccessful block. Therefore, it is important for growers to have knowledge of rootstock performance when grown with varieties important to the region and with the climatic conditions experienced in the region. The objectives of the study reported here were to compare performance of several of the newest rootstock clones with a variety of increasing importance to retail orchardists.

Materials & Methods

In April, 1995, a trial was established at the University of Massachusetts Cold Spring Orchard Research & Education Center in Belchertown. It included Ginger Gold trees on ten different rootsocks. The experiment was conducted in a randomized-complete-block design with ten replications. Annually, trunk cross-sectional area, yield, and fruit size were measured.

Results

At the end of the 2001 growing season (seventh leaf), trees on Mark and V.1 were the largest, as assessed by trunk cross-sectional area (Figure 1). Please note that in a number of research and commercial plantings Mark has grown vigorously during the first few years, matching trees on M.26 in size. After 6-8 years, however, they usually begin

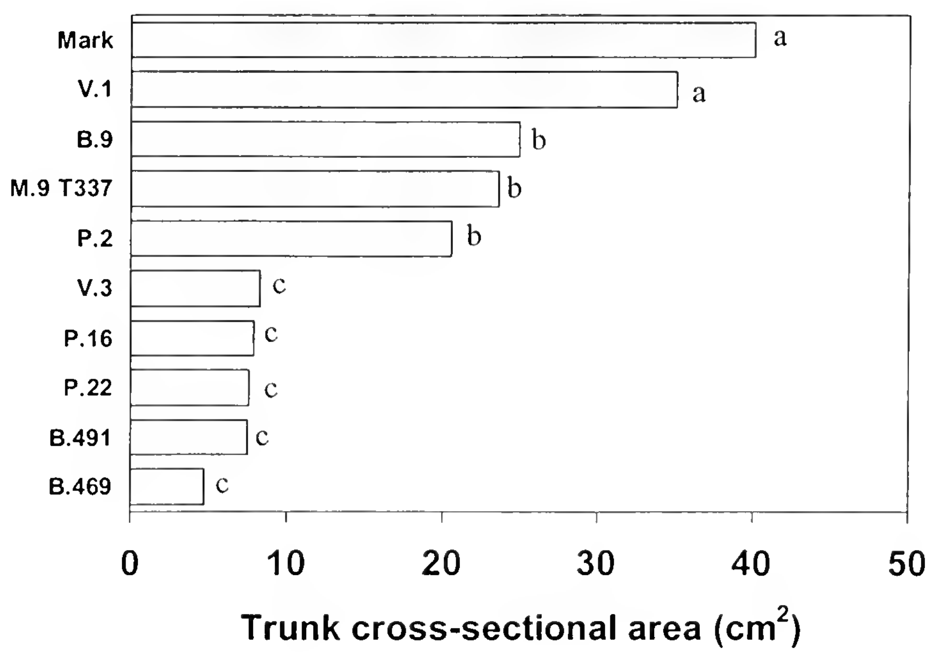

Figure 1. Trunk cross-sectional area in 2001 of Ginger Gold trees on several rootstocks planted in 1995. Bars not followed by the same letter are significantly different at odds of 19 to 1.

Table 1. Yield, yield efficiency, and fruit weight in 2001 of Ginger Gold trees on several rootstocks planted in 1995.[z]

	Yield per tree (kg)		Yield efficiency (kg/cm^2 TCA)		Fruit weight (g)	
Rootstock	2001	Cumulative (1997-2001)	2001	Cumulative (1997-2001)	2001	Average (1997-2001)
B.491	1 b	13 c	0.2 a	1.7 ab	208 ab	207 a
P.2	2 ab	32 cd	0.1 a	1.6 ab	209 ab	212 a
P.22	1 b	12 e	0.2 a	1.7 ab	189 ab	201 a
V.1	3 ab	49 ab	0.1 a	1.4 ab	203 ab	218 a
V.3	1 b	11 e	0.1 a	1.1 b	184 ab	200 a
B.469	0 b	7 e	0.1 a	1.3 ab	144 b	130 b
P.16	1 b	16 de	0.1 a	2.0 a	202 ab	202 a
B.9	6 a	35 bc	0.3 a	1.5 ab	223 ab	224 a
M.9 T337	3 ab	39 bc	0.1 a	1.7 ab	238 a	215 a
Mark	3 ab	65 a	0.1 a	1.6 ab	244 a	206 a

[z] Means within columns not followed by the same letter are different at odds of 19 to 1.

fruiting heavily and often stop growing unless special care is taken. Trees on B.9, M.9 T337, and P.2 were similar in size but smaller than those on Mark or V.1. The smallest trees were on V.3, P.16, P.22, B.491, and B.469. This last group, in general, was in the subdwarf size category. It is important to note, however, that trees on V.3 in other research trials with different varieties have been in the M.9 range rather than the subdwarf category.

Yield in 2001 was very low in this trial due to an early May frost. Cumulative yield (1997-2001), however, was significantly differences among rootstocks (Table 1). Generally, however, cumulative yield followed tree size, with the largest trees producing the greatest amount of fruit. Yield efficiency is a statistic that relates yield to tree size. As might be expected because of the close relationship between cumulative yield and trunk cross-sectional area, there was little difference in cumulative yield efficiency (Table 1). The only statistically significant difference was that trees on P.16 were more efficient than those of V.3.

Fruit size in 2001 and on average from 1997 through 2001 was relatively consistent among trees on the different rootstocks (Table 1). The only rootstock which appears to affect fruit size negatively was B.469. Fruit from these trees was only two thirds the size of fruit from other trees on average.

Conclusions

This trial is still relatively young, and with a poor year in 2001, we are not prepared to make any definitive conclusions at this time. However, it points to a few possible practical outcomes. First, among the subdwarfs, P.16 appears to be the best. It has consistently (among a number of studies) has performed well, producing good yields with good fruit size, both of which are difficult in general for trees on the subdwarf rootstocks. Second, M.9 and B.9 continued to perform similarly and well. Last, V.1 looks interesting for an M.26-sized tree. In other research trials, trees on V.1 have yielded significantly more than comparable trees on M.26.

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Fruit Notes

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